TAMPERE UNIVERSITY OF TECHNOLOGY
Degree Programme in Civil Engineering

RISTO SEPPÄNEN
WATER NETWORK MANAGEMENT IN KEETMANSHOOP, NAMIBIA
Master of Science Thesis

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ABSTRACT

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Due to extreme water scarcity in Namibia, water losses are a widespread problem for local authorities, causing water shortage, drought and financial losses. In the light of the climate change and growing water shortage throughout the world, significant actions must be made to stop fresh drinking water wasting and to reduce high percentage of water losses. Municipalities of Keetmanshoop and Ondangwa are part of a partnership project (PLDDSI) between four municipalities in Finland and Namibia. As a part of the partnership, engineering assistance was provided from Finland and Namibia to sort out the matters and give suggestions to handle them.

This research concerns mainly water network management in the Municipality of Keetmanshoop but for comparison and as a basis for the analysis, a number of other municipalities and their water departments are analyzed. The additional municipalities subjected to closer scrutiny were Windhoek, Swakopmund, Ondangwa, Omaruru and Lüderitz in Namibia. The Finnish reference municipalities are PLDDSI counterparts: Lempäälä and Kangasala. The main objective of this research was to analyze the problems what Namibian municipalities are encountering with water distribution systems and suggest improvements. Mainly, all the issues accumulate to high amount of wasted water due to physical problems in the network, such as leaking pipes and non-working valves as well as insufficient management. All the studied municipalities pointed out and emphasized different reasons for water losses but more or less, they were the same in each municipality.

Methods of management in Namibian municipalities varied broadly; in some of them, the lack of care for the distribution network was anxious whereas other municipalities had clear plans for development and routine maintenance. Nevertheless, all them were in the same line, what came to unmeasured water caused by illegal connections and unrecorded consumption, all municipalities considered these as substantial issues due to difficult management.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO
Rakennustekniikan koulutusohjelma
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Namibia on eteläisen Afrikan kuivin valtio, joka kärsii äärimmäisestä veden niukkuudesta. Maan vesijohtoverkostojen vuodot ja vesihäviöt ovatkin suuri ongelma kunnille sekä taloudellisesti että yleisten vesivarojen vähyyden johdosta. Kiihtyvässä ilmastonmuutoksessa ja kasvavassa veden puutteessa ympäri maailman merkittäviä toimenpiteitä on tehtävä puhtaan juomaveden tuhlaamisen ja suurten vesihäviöiden estämiseksi. Keetmanshoopin ja Ondangwan kunnat ovat osa neljän kunnan suomalais-namibialaista kehitysyhteistyöprojektia (PLDDSI), jonka eräänä päämääränä on antaa insinööriapua näiden ongelmien löytämiseksi ja ratkaisemiseksi.

Tämä tutkimus koskee vesijohtoverkoston hallintaa Keetmanshoopin kunnassa, mutta vertailun vuoksi esitellään myös muita namibialaisia kuntia ja niiden vesijohtolaitoksia. Tarkasteltavat kunnat ovat Windhoek, Swakopmund, Ondangwa, Omaruru ja Lüderitz, joiden lisäksi projektin suomalaiset osapuolet Lempäälä ja Kangasala ovat osana vertailupohjaa. Tutkimuksen päätavoitteina on eritellä namibialaisten kuntien kohtaamat ongelmat vedenjakelujärjestelmissä sekä tuottaa niihin ratkaisuja ja kehityskeinoja. Suurin osa vesijohtoverkoston ongelmista on luonteeltaan fyysisiä; vuodot ja heikko infrastruktuuri, joiden taustalta usein paljastuu verkostojen riittämätön hoito ja hallinta. Kaikki tarkastelussa mukana olleet kunnat painottivat hieman eri syitä vesihäviöihin, mutta kaiken kaikkiaan ne olivat lähes samat jokaisessa tarkastellussa kunnassa.

Namibialaisten kuntien vesijohtoverkostojen hallintamenetelmät olivat keskenään hyvin erilaisia. Joissakin kunnissa puutteellinen ylläpito oli suurin ongelma, mutta toisissa oli selkeitä kehitystavoitteita ja huolto-ohjelmia. Eroavaisuuksista huolimatta kunnilla ilmeni samoja vaikeuksia laittomien liitosten seurauksena sekä mittaamattoman ja muistiin merkitsemättömän kulutuksen vuoksi. Kaikki kunnat pitivät näitä ongelmia suurina vaikean hallinnan vuoksi.

PREFACE AND ACKNOWLEDGEMENTS

This research was made in the Municipality of Keetmanshoop in Namibia and Master's thesis compiled in Tampere University of Technology, Finland. A significant share of the inputs into this thesis was collected during the surveys to the reference municipalities in Namibia and Finland but the main emphasis of this research is on Keetmanshoop. However, all information can be used in other municipalities with local revisions.

First and foremost, I wish to express my gratitude to my colleague Namibian student Andreas Angula, who devotedly and passionately participated in the fieldwork and assisted me in the project in every way possible. I thank him for the support and being my friend during the research period and after that.

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- Mr. Markus Moses, Data processor
- Mr. Bertie Reyneke, The Strategic Executive: FED, The Acting CEO
- Mr. Andre Blauuw, The Strategic Executive: CAHR
- Mr. Nimrod Zwartz, Building Inspector, The Acting Chief Technician
- Mrs. Joey O'Connell, CEO's assistant
- Other staff of the Municipality for unprejudiced and kind assistance during the project

Furthermore, some data was gathered in meetings and interviews from relevant municipalities and bureaus through the country thus special thanks belong to technical managers in Windhoek, Swakopmund, Ondangwa, Omaruru, Karibib and Lüderitz as well as NamWater's managers in Windhoek and Keetmanshoop. In Finland, technical managers of water departments in Kangasala and Lempäälä deserve also my appreciation.

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Tampere, 25th of November 2008

Risto Seppänen

ABBREVIATIONS AND NOTATION

AC	Asbestos cement
CAD	Computer aided design
CAHR	Keetmanshoop Municipality: Department of Corporate Affairs and Human Resources
CEO	Chief Executive Officer
DBTP	Decentralized Build Together Programme
FED	Keetmanshoop Municipality: Department of Finance and Economic Development
ITS	Keetmanshoop Municipality: Department of Infrastructure and Technical Services
MRLGH	Ministry of Regional and Local Government and Housing
MRLGHRD	Ministry of Regional and Local Government, Housing and Rural Development
NamWater	Namibia Water Corporation Ltd
PLDDSI	Partnership for Local Democracy, Development and Social Innovation
PE	Polyethylene
PP	Polypropylene
PVC	Polyvinyl Chloride
UFW	Unaccounted-for water
uPVC	Unplasticized Polyvinyl Chloride (also known as rigid PVC)
VAT	Value Added Tax (Namibia 15%, Finland 22%)
WASP	The Water Supply and Sanitation Policy of 1993
WPI	Water Poverty Index

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1. INTRODUCTION

1.1. Background

Because water is a basic need for all human activities, are proper water distribution networks essential in the areas of high density of population. In a water distribution network, water is transferred through pipes or channels to serve all points of the town. In Keetmanshoop and generally in Namibia, systems and networks are relatively old because most of them have been constructed under the South African colonial period long before 1990s. It indicates that pipes and parts have usually been made of cast-iron and asbestos cement, which were the most available and cost-effective materials for building water distribution networks at the time. At the moment these old system are becoming very fragile and often municipalities encounter problems with bursting pipes, leaking shut valves, non-functioning pumps and so forth. That naturally causes many problems including financial loss, shortage of water, drought and unsatisfied residents. Problems magnify when there is a lack of proper management and municipalities do not have resources to deal with them. Taking into consideration population growth and development alone, it is predicted that the demand for water in Namibia will exceed the extraction capacity by 2015. In light of climate change and the associated projected increase in evaporation rates, water resource and network management will continue to be of the utmost importance to resource management and planning in Namibia. (REEECAP 2008, 2)

PLDDSI (Partnership for Local Democracy, Development and Social Innovation) is a development project between four similar size municipalities in Finland and Namibia. The Finnish counterparts are municipalities of Lempäälä and Kangasala and Namibian partners are municipalities of Ondangwa and Keetmanshoop. The overall aim of the partnership is to promote cross-cultural cooperation between both countries, and development of water services in both Namibian municipalities is one part of the partnership. (PLDDSI 2008). The major cooperating partners are Tampere University of Technology in Finland and Polytechnic of Namibia by providing professional engineering assistance and students for fieldwork to gain work experience and to compile their final thesis or final projects. In this case two civil engineering students, one from Finland and one from Namibia, were sent to Keetmanshoop, for a two-month period starting July 2008 end of August 2008, to investigate the problems what Municipality of Keetmanshoop was encountering with water issues.

1.2. Objectives

The overall aim of the task is to produce concrete information on water network management practices and suggest measures for improvement for Keetmanshoop as well as to promote the maximum beneficial use of the municipalities' water supply and to safeguard water supplies along the water network. The bulk of the work was done in Keetmanshoop, in order to get a thorough understanding on the operation of the water distribution system – technical, financial and human resource aspects included.

For comparison and as a basis for the analysis of the current practice in Keetmanshoop, a number of other municipalities and their water departments are analyzed. In Namibia, the municipalities studied are Ondangwa, Lüderitz, Swakopmund, Omaruru and Windhoek. In addition, to get an international perspective, both Finnish PLDDSI partner municipalities Lempäälä and Kangasala, with populations similar to Keetmanshoop, were analyzed. The purpose of this selection is not to generalize the whole management practice in Namibia but to point out how different they can be.

1.3. Structure and scope of the research

This research looks at water distribution services mainly in Keetmanshoop but gathers the basic information of six Namibian and two Finnish municipalities under the same cover. The scope of the research is to concentrate only water network management excluding detailed analyses on the water network infrastructure hence no structural or operation analyses are included in this study. Such items as wastewater, sewerage and storm water will be mentioned in relevant connections but not handled as major subjects. This arrangement and problem formulating was produced together with PLDDSI partners in order to focus on the most problematic issues and to keep the wideness of the scope realistic for Master's thesis' scale.

The Namibian reference municipalities were chosen by similarities or other interesting details what could be useful for understanding the whole variety of water distribution practices in Namibia. Due to relatively similar population size to Keetmanshoop, Ondangwa, Lüderitz and Swakopmund were chosen to be part of the study. Swakopmund was also known to have a well-established and operating water department and thus it would give a nice comparison for the rest. Although, Omaruru is a fairly small town, it is a good example of a municipality, which has its own water source while all other Namibian references are mainly dependent on monopolistic bulk water supplier, NamWater. Furthermore, Windhoek is analyzed to give an idea of a very professional water department even though its size class is very different from Keetmanshoop.

The research itself is described in seven chapters. Chapter 2 introduces background information in order to understand the issues more deeply. Chapter 3 explains the research strategy and methods used to compile this research.

Chapters 4, 5 and 6 analyze the current situation in the selected municipalities and countries in general. Chapter 4 concentrates on Namibian municipalities, introducing national water legislation, water sources, typical losses, and financial contribution and water management practices. Chapter 5 studies Keetmanshoop itself, paying special attention on detailed routine activities and local problems. Chapter 6 approaches Finnish water management system and compares it to Keetmanshoop's practices.

Chapter 7 discusses about the need and procedure of this research as well as evaluates author's input. Chapter 8 reviews the research carried out, presents conclusions and recommendations.

In order to understand economical values more easily between Namibian and Finnish municipalities, Finland's currency Euro is converted to Namibian dollars in accordance with Bank of Finland. However, while doing the research, exchange rates varied a lot thus an average was chosen between the minimum and maximum rates from June 2008 to November 2008. In this report, used exchange rate is 1 € = 13 N$.

2. PROBLEM FORMULATION

2.1. Theoretical Background

The subject of water network management has not been studied too much in Namibia. According to literature survey, strictly scoped studies towards water network management where hard to find but for instance water resources management has been studied broadly. It is easy to understand, water scarcity and adequacy of water in the future are not only national concerns but also international. National, UN and international cooperation projects, concerning availability of water, are common in the country and references are easy to find. Proper plans are made to use water sources and to carry water without dissipation to its destination (for example town) but what comes to the local distribution systems, closer concern is needed. If a town loses one third of the purchased water from the bulk supplier, major planning has not been sufficient and local distribution capabilities have not been taken into consideration. The conditions of sustainable development have not been met.

According national development plans, local distribution systems are not considered as spearhead targets for development or even upkeep. Development and management of the distribution systems are in hands of the municipalities, which are funded through regional councils (does not concern Part 1 municipalities, see Chapter 4.1.) and by its own revenue. If they are poor or do not consider water network management as an essential topic, municipalities are not in good basis for managing their water infrastructure. That gives the idea of the source of the problems. However, the richest municipalities, with long tradition of European engineering, are technically at same level than typical European municipalities.

2.2. Research Questions

In accordance with PLDDSI goals on water services, the main purpose of the project is to build capacity to minimize environmental damage and economical losses caused by water leakages in Keetmanshoop. To achieve this goal, following research questions must be answered:

- What is the current condition of water network management practice in Keetmanshoop?
- What is the condition of the water infrastructure?

- What are the reasons for water losses?
- What are the primary and the secondary development methods?

3. METHODOLOGY

This chapter gives an outlook to the research methods and the process of this study. Research can be carried out in many ways using a variety of approaches, which can be based on different research strategies or project designs. Research strategy or project design determines how the research question(s) will be answered, investigations will be done and how data will be obtained. (Hirsjärvi, Remes & Sajavaara 1997, 128; Brewerton & Millward 2001, 52–53). Tools for gathering information are included under methodology and actual tools are research methods, which are typically either quantitative or qualitative. The objective of qualitative research is to understand phenomena while in quantitative research the objective is to make statements that have predictive power and consider mainly on quantifiable values (Stainback & Stainback 1988). Nevertheless, always these two approaches are not clear, and it is hard to find research that is purely qualitative or quantitative (Alasuutari 1999, 32).

The leading research strategy is case study and main data collecting methods are semi-structured interviews, equipment tests, observation and literature survey.

3.1. Case study

Case study is usually considered as a purely qualitative approach and is defined as a research, what studies current event or an acting individual in a certain environment, using diverse and large-scale obtained data (Yin 1983, 23). Alternatively, according to Gomm, Hammarsley & Foster (2000, 2–3), definition can be only shortly generalized as an *intention to produce intensive and detailed information of the studied case*. Anyway, the nature of case study research is usually to understand a certain phenomena more deeply to provide steps for clear improvements (Cohen & Manion 1995, 123). The target of the research can be a single case, situation or group of cases, targeting a single person, a society or an organization and its processes (Hirsjärvi, Remes & Sajavaara 1997, 131).

In general, there is only one object in a case study. The purpose is to say as much as possible about small thing unlike only a little from a big thing. Usually more interesting is to be acquainted with the logic and formulation of the phenomena unlike studying the generality of it. In this research, Keetmanshoop represents the case study object but for obtaining comparative information that can be used for improving the current system, references are needed. Thus, case study can be realized as a two or more objects' comparative study and it is usually used in cases where organizations or certain activities are compared together. (Jokinen & Kuronen 2002)

Case study is often connected to qualitative research excluding empirical and quantitative aspects (Gomm, Hammarsley & Foster 2000, 2–5). Usually, the preferred sources are data collected in natural situations such as video tapes, records, notes, documents or the like. However, the research nature encourages collecting information broadly using different means and angles, providing also the possibility to use quantitative methods. (Jokinen & Kuronen 2002). In this research, data have been collected using many means and methods, and this procedure has been found very useful.

The advantages of this research strategy, according to Brewerton & Millward (2001, 53) with some alterations, are presented in the following list:

- It allows generalization.
- It enables a more in-depth examination of a particular situation than other strategies;
- The information it yields can be rich and enlightening and may provide new leads or raise questions that otherwise might never have been asked.
- The people involved usually comprise a fairly well-circumscribed and captive group, making it possible for the researcher to describe events in detail.
- Reports are possible to compile in a popular form thus the research may serve diverse audiences.

Due to the scope of this research, it is inevitable that some information will be left on the generalization level. It is impossible to obtain very accurate data in such a short research period and form strictly valid research information. However, data collected from Keetmanshoop represents the current situation quite accurately due to daily observation and close scrutiny. As stated, case study supports also popular form of reporting, which is useful in this situation where “common people” have to be reported and convinced. In this case, staff of the Keetmanshoop Municipality and Town Council are the final targets of this research, not professional water engineers, making the clear reporting essential.

3.2. Procedure of the research

When doing a research, researcher always tries aspiring validity by avoiding mistakes and making qualified job. However, in the end, research’s validity will be measured and one way is to judge research’s reliability, meaning measurements repetitiveness. (Hirsjärvi, Remes & Sajavaara 1997, 226)

Before starting a case study research project, these matters should be kept in mind in order to make the research more understandable and to give clear vision how it has been done. In this way, researcher gives the possibility for the audience to test the results and argue them more efficiently hence “better” result will be provided. Due to reliable base and methodology of this study, Keetmanshoop Municipality has been provided with knowledge how to continue or repeat the measurements by themselves to deepen the information gathered.

However, in practice, two students from Tampere University of Technology and Polytechnic of Namibia, namely Risto Seppänen and Andreas Angula respectively, were appointed to carry out the task under the supervision of DSc Pekka Pietilä from Tampere University of Technology. Procedure was simple, after two months surveying period in Keetmanshoop and reference municipalities, the Finnish student returned to Finland and continued studies with two Finnish counterparts while the Namibian student started a detailed analysis on the Municipality of Ondangwa. During these researches, this Master's thesis and detailed reports of both PLDDSI Namibian municipalities were compiled.

3.2.1. Semi-structured interviews

Semi-structured interview, also known as theme interview (Laadullisen tutkimuksen käsikirja 2006, 115), is typical method if strict question pattern does not exist but topics are known. It is usually considered as a combination of using clearly structured query forms and open discussion. It is widely used in qualitative research but has also been proven useful in quantitative based studies due to easy result analyzing possibilities (for example frequencies). (Hirsjärvi, Remes & Sajavaara 1997, 203)

In general, interview is an extremely flexible research tool. It can be used at any stage of the research process: during initial phases to identify areas for more detailed exploration and/or generate hypotheses; as a mechanism for data collection; and as a "sanity check" by referring back to original members of a sample to ensure that interpretations made from the original data are representative and accurate. However, it has some disadvantages. Interviews are always time consuming, open to bias and reliability of the results can be poor. (Brewerton & Millward 2001, 69–74). During the research, many of the results had to be checked again from other sources (for valid data), making the research process very inefficient.

During the period in Namibia, several people were interviewed from related offices and bureaus such as MRLGHRD, Karas Regional Council's office, National Planning Commission and NamWater's offices as well as other municipalities around the country. However, due to target of this research, the main source of information was naturally Keetmanshoop Municipality's officers and staff. In Finland, theme interviews were held also with municipalities' water department authorities before and after the research period in Namibia.

3.2.2. Observation

If the data can be collected in a situation when the object is behaving normally, observation gives the information how the people are really acting. However, sometimes, when a person is under observation, behavior may differ from normal. Usually, this method is not used in short projects because the observed has to get used to the observer and it is time consuming. (Hirsjärvi, Remes & Sajavaara 1997, 209). Nevertheless, in this case method was proven rather useful although time was short.

There are two broad types of observational activity: participant and non-participant. With participant observation, the researcher immerses him or herself in a situation alongside participants in the field. The aim is to become an accepted member of the participant community, which may cause “overparticipation” and results will be affected by researcher’s own emotions. In non-participant observation, the focus of the observation is usually at the macro-level and done outside of the community, giving advantage that researcher does not identify as community member and keeps the role of a pure researcher. (Laadullisen tutkimuksen käsikirja 2006, 116–117; Brewerton & Millward 2001, 96–97)

During this research, non-participant role was assimilated and method was used for example to follow plumbers’ daily routines.

3.2.3. Equipment tests

An equipment test is useful method for deepen the information gathered through interviews and observation as well as getting purely valid data. Interviews and observation are “soft methods”, which do not always provide sufficiently reliable information thus properly executed equipment tests are often necessary to supplement qualitatively gathered information. Purely technical studies are always realized with extensive and carefully executed equipment tests.

In this research, some equipment tests were made in Keetmanshoop to understand the current situation better. For example, Chapter 5.3.2. introduces the experiment made to the residential water meters and Chapter 5.4.3. calculation for water wasted through buildings’ poor sanitary equipment.

3.2.4. Literature survey

An extensive literature survey is an essential resource for understanding the research subject and helps the researcher to focus on the most meaningful topics. In this study, a lot of time was spent on investigating Municipal data in Keetmanshoop. Although it is not traditional literature, it is a significant input to this research. In addition, some information was gathered from related articles and books in National Archives, National

Library and Polytechnic of Namibia as well as from libraries in Finland and electronic articles from internet databases.

Table 3.1. summarizes how different research methods have been used at various stages of the research.

Table 3.1. *Use of different research methods*

	Research method used			
RESEARCH STAGE	Interviews	Observation	Equipment tests	Literature survey
Introducing Chapters				
1. Introduction	x			x
2. Problem Formulation	x			x
3. Methodology				x
Main Chapters				
4. Water Services in Namibia	x			x
5. Analysis on Keetmanshoop	x	x	x	x
6. Comparison to Finnish Municipalities	x			x

As it seems, most of the detailed analysis has been done in Keetmanshoop. However, more detailed studies in other municipalities would have deepened the information considerably but due to time limit and wideness of the scope, additional studies were forced to leave out.

4. WATER SERVICES IN NAMIBIA

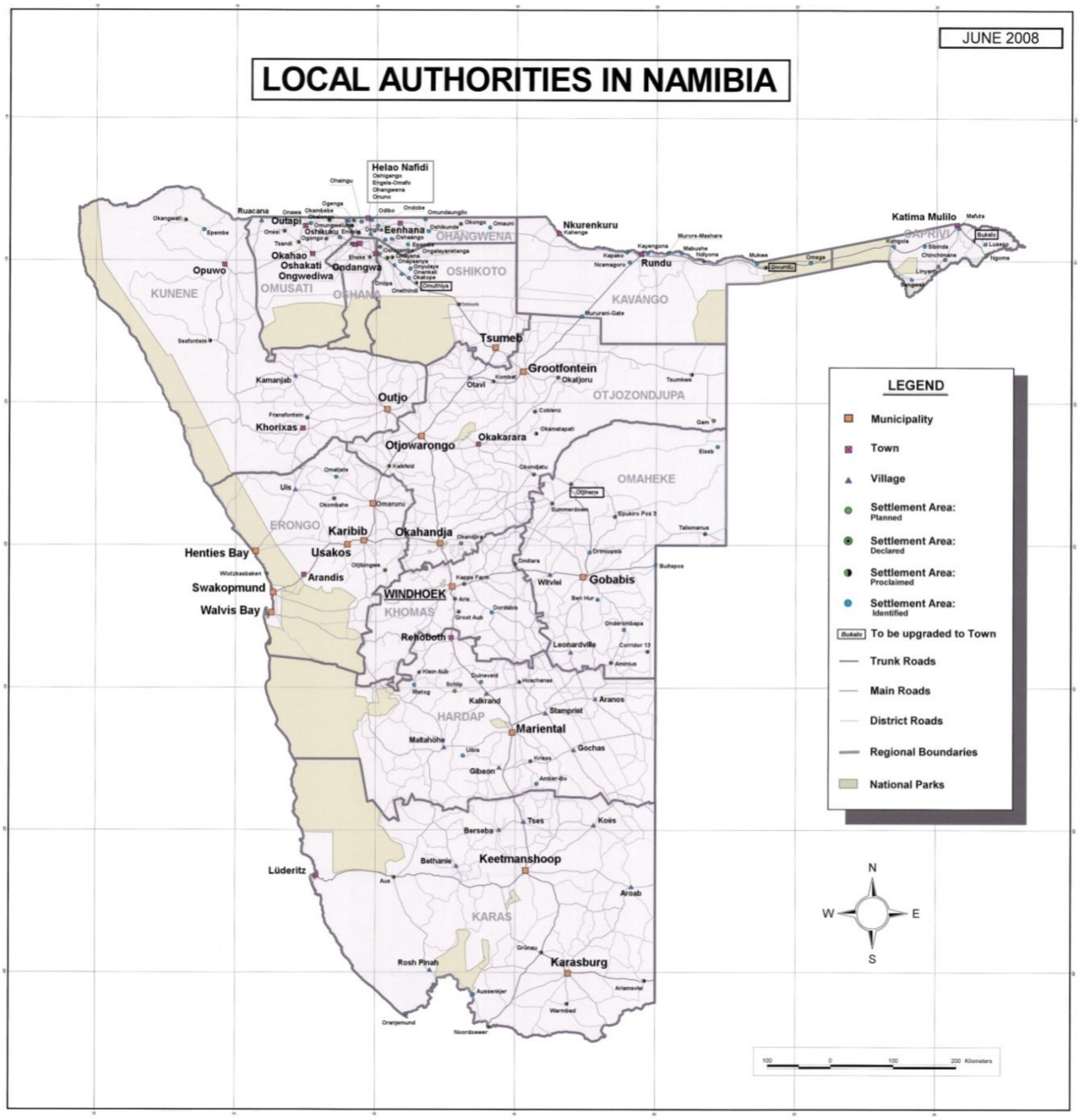
4.1. General information and legislation

Namibia is the most arid country south of the Sahara, stretching over a total area of 825 418 km^2. The population, growing at the rate of 3% per annum, is estimated to be 1 820 916 million in 2008, of which 70 % is rural and 30 % urban. (Ministry of Environment and Tourism, 2001; Wikipedia 2008: “Namibia”). Country suffers from extreme water scarcity. Annual rainfall is low and ranges from virtually zero along the coast to a maximum of 700 mm in the extreme northeast. The only permanently flowing rivers lie near to, or from part of, the country international boundaries. The lack of readily available fresh water in the interior of the country remains the most important limiting factor for development. (Namibian Vision 2030, 2004, 136). See Photo 4.1. for typical view over the landscape in southern part of the country.

Photo 4.1. *General view over the Municipality of Keetmanshoop. Annual rainfall has ranged from 60 mm to 290 mm for last ten years (Namibia Meteorological Services 2008). © Risto Seppänen 2008*

In accordance with Local Authorities Act (1992), Namibia is divided into thirteen (13) political regions, each headed by a Regional Council, which forms the second tier of the

Government. The third tier of governance is formed by 45 local authorities, who are divided into four different categories: Part 1 Municipalities, Part 2 Municipalities, Towns and Villages. See Figure 4.1. for map and list of local authorities in Namibia. Municipalities are able to exercise and perform the powers, duties and functions conferred and imposed on them in terms of the Local Authorities Act. Part 1 Municipalities have to generate their own funds, while Part 2 Municipalities receive limited financial assistance from the Government. Towns and Villages are under the more direct supervision of the Ministry of Regional and Local Government, Housing and Rural Development (MRLGHRD). (Holtzhausen 2003, 8)



Classification in 2004	
Part 1	Windhoek, Walvis Bay, Swakopmund
Part 2	Gobabis, Grootfontein, Hentiesbaai, Karibib, Karasburg, Keetmanshoop, Mariental, Okahandja, Omaruru, Otjiwarongo, Tsumeb, Outjo, Usakos
Towns	Arandis, Eenhana, Katima Mulilo, Khorixas, Lüderitz, Okakarara, Ondangwa, Ongwediwa, Opuwo, Oshakati, Outapi, Rehoboth, Rundu
Villages	Aranos, Aroab, Berseba, Bethanie, Gibeon, Gochas, Kalkrand, Koës, Leonardville, Maltahöhe, Otavi, Stampriet, Tses, Uis, Witvlei

Sources: Map: MRLGHRD 2008
List: Local Authorities Act 2001, Schedule 1–3 (96–99)

Figure 4.1. *Map and list of local authorities in Namibia*

Water network management is a responsibility of the local authorities. According to Local Authorities Act (1992, 30.1.a-b), the main function of a local authority is service delivery, including provision of water and operation of a sewerage system. The Act also empowers local authorities to compile their own regulations and rules to govern the quality of service delivery and standard of supply but it does not provide any guidance nor is it prescriptive in terms of norms and standards. (Pietilä 2005, 56)

In general, water development and use is being regulated by: a) The Water Act, Act 54 of 1956, b) The Water Supply and Sanitation Policy (WASP) of 1993 and c) Namibia's Environmental Assessment Policy of 1994. The Water Act empowers the ministry responsible for water affairs to investigate, plan, develop, allocate, conserve, control and manage the water resources of Namibia. The outdated Act needs revision to address the current Namibian situation. The WASP provides guiding principles for water development and use, and these principles are encompassed in the National Development Plan. The Environmental Assessment Policy calls for integrated planning to assure that the benefits from water use are maximized while minimizing the negative impacts. (Pietilä 2005, 56). The Ministry of Regional and Local Government and Housing have compiled Model Water Regulations for Namibia, which are used by most local authorities. In addition, South African standards and guidelines are used widely. (Holtzhausen 2003, 16–17)

4.2. Water resources and suppliers

Water is obtained from three natural sources: groundwater, perennial surface water supplied by the rivers that form the northern and southern boundaries of Namibia, and ephemeral (or seasonal) surface water from rivers within the country that only flow after especially long rains. About half of Namibia's water is supplied from groundwater; the rest is split between perennial and ephemeral surface water, 27% and 22%, respectively. (Lange 1997, 303)

Two different institutions were established to deliver water to end users: the publicly administered bulk water supply (Namibia Water Corporation Ltd, NamWater) and rural water supply. Bulk water supply relies on relatively large-scale dams, transport, and storage technology to supply urban areas and commercial agriculture. Rural water supply utilizes small-scale, localized technology (mostly boreholes) and does not generally transport water over large distances. Rural water supply is partly the responsibility of the government (Ministry of Agriculture, Water and Rural Development) and partly provided by users for own use at their own expense under some supervision by the government. (Lange 1997, 303)

The Namibia Water Corporation Ltd (NamWater) was established in 1997 and was incorporated as a limited liability company under the provisions of the Companies Act (1973). In April 1998, the government transferred all assets relating to the bulk supply of water from the Department of Water Affairs to NamWater. The state is the sole shareholder and owner of the corporation and is represented by the Ministry of Agriculture, Water and Forestry. (Bayliss 2005, 12)

In most of the cases, NamWater is the bulk water supplier to the outskirts of the towns but in rural areas NamWater supplies water directly to the farms and informal settlements. However, some towns, such as Omaruru, Tsumeb and Grootfontein, have their own water sources such as prosperous and clean aquifers. The total domestic water consumption of Namibia is approximately 300 000 000 m^3/year (Encyclopedia of Earth 2008). According to the 2001 Population and Housing Census, National Report (2003) 87% of all households in Namibia have access to safe water. More than half of the households have piped water within their compounds, while another 35% of them get their water from public standpipes and boreholes.

4.3. Water network management in the related municipalities

Municipalities' technical departments have a rather wide variety of responsibilities; one of them is water network management, which consists of network operations, maintenance, new developments and water distribution. In addition, technical departments are also commonly responsible of sewerage, wastewater treatment, refusal disposal and municipal properties' maintenance such as stores, parks, sport grounds and cemeteries. In situations where the local authority is incapable, due to shortage of manpower or knowledge and skills of realizing new developments, private contractors and consultants are hired for carrying out the tasks. For example, currently in Omaruru, commercial help is needed due to high need of servicing new development areas. Omaruru is struggling with the lack of workers; in June 2008 11 of 18 Technical Department's posts were vacant.

The responsibilities between bulk water supplier (NamWater) and the municipalities are normally sorted out in that way that NamWater responsibility ends after water meters at the inlets of town's supply pipelines and after that municipality takes the responsibility of water distribution. Normally, in the house connections municipality's responsibility extends to the valve (if it exists) after the consumer water meter. In case of development and servicing new areas, pipelines are built by the municipality or private contractor until the consumer water meter but after that, the responsibility moves to the owner of the plot.

The municipalities reviewed in this chapter are Windhoek, Swakopmund, Ondangwa, Lüderitz, Omaruru and Keetmanshoop. Basic information can be obtained from Table 4.1., where, for comparison, Finnish municipalities have been also included.

Table 4.1. *Basic information of the related municipalities.*

	Urban population	Water suppliers
Windhoek	233 529[1]	NamWater 75%, own boreholes (50) and reclaimed water 25%
Swakopmund	23 808[1]	NamWater
Ondangwa	10 900[1]	NamWater
Lüderitz	13 295[1]	NamWater
Omaruru	4 761[1]	Groundwater (own water supply)
Keetmanshoop	15 778[1]	NamWater + three own boreholes
Lempäälä	19 271[2]	Groundwater (own water supply), Tampere Water, Valkeakoski
Kangasala	27 733[2]	Groundwater (own water supply), Tampere Water (emergency)

Notes: 1) Urban population in 2001
2) Urban and rural population in 2008
Sources: 1) 2001 Housing and Population Census, National Report, 2003
2) Statistics Finland, populations 1.1.2008

Municipalities are commonly dependent on NamWater's water supply although Keetmanshoop and Windhoek have few own water sources. Omaruru is an exception with a totally independent water supply due to rich and extensive aquifer which, according to a recently made research, supplies water at least for seven years even though the land would suffer significant drought. Keetmanshoop supports itself with three own boreholes and treated water coming through NamWater pipes from Naute Dam. Towns at the Atlantic coast are dependent on water supplied by NamWater, which makes them vulnerable for water shortages. Due to huge uranium mining boom in the coastal area, demand of water will significantly become bigger and it will be a problem, which has not yet been sufficiently solved.

4.3.1. Water distribution networks

In the studied municipalities, water distribution networks are rather old. Most of the oldest parts have been built in 1950s and currently every municipality is having problems with them; cast-iron pipes are getting rusty and asbestos cement pipes are getting fragile and sensitive to pressure peaks. Due to weakness of the pipes, they tend to leak and it is the biggest reason for water losses that has been encountered in each municipality. Swakopmund and Windhoek have overall plans to replace all of the old pipes in the next 10 years but for example, Keetmanshoop is struggling with a weak financial situation and a lack of proper plans. Anyway, in each municipality, uPVC has been decided to be the main pipe material for new development areas, and again polyethylene as well as uPVC pipes and galvanized steel are normally used for house connections. Pipe pressure classes are commonly from six to twelve kilopascals but Lüderitz's Technical Department has made a decision to use everywhere class 16 pipes to avoid bursts made by pressure peaks. However, this practice sounds a little too over-calculated to make it cost-efficient. Some of the municipalities use also GRP (Glass

Reinforced Plastic). In the coastal areas, steel and cast iron pipes are not used at all due to climate conditions.

In general, water network mapping has been done quite well in these municipalities; all "master plans" are from this decade. However, before the PLDDSI partnership started in 2007, Keetmanshoop's latest water network layout was from 1980s. The project produced new water distribution network layout for the town as well as for Municipality of Ondangwa. Currently the mappings are fairly up-to-date and the most developed municipalities, Windhoek and Swakopmund, use frequently updated soft-copies (CAD) to operate the system. The soft-copies exist for each municipality, and can be achieved from Ministry of Regional and Local Government, Housing and Rural Development, but are not used widely due to lack of knowledge of soft-systems and ignorance to updating processes. In the most developed municipalities, Windhoek, Swakopmund and Lüderitz, operational parts of the networks such as shut valves and fire hydrants, are documented and marked properly on the spot. For example in Swakopmund all underground fire hydrants are numbered and covered in man-holes as well as marked with clear yellow color. Moreover, similar marking method is used for shut valves. However, in other towns marking and covering methods varies so much that for instance in an emergency situation a critical shut valve cannot be operated because plumbers cannot find it; even it is marked on the water network layout. In the worst-case scenarios, critical shut valves are buried under the tarred roads without clear connections to the surface. However if the shut valve is found, it is not always sure that it works. Some of the old shut valves have not ever been replaced and maintained and thus these shut valves may not open or close sufficiently at all.

In studied municipalities, quality of water is mostly good, drinkable (class B, NamWater's qualification) and most of the plots are serviced by water either inside the house or at least inside the plot. Keetmanshoop has serviced all plots and Swakopmund is planning to service all the houses in the near future. Still most of the informal settlements are serviced by standpipes (prepaid water meters). Only problems with water quality are remains of medicines (Windhoek), hardness and lime. Due to that, for example in Swakopmund, it is very common that every household has its own "filter" (some kind of box filled with crystal particles), just after the water meter, to filter out the lime particles. Filter has to be changed in one-year periods and replacements are commonly available in the coastal municipalities such as Walvis Bay and Swakopmund.

4.3.2. Consumer water meters and meter reading practice

Nearly all consumers have water meters. Municipalities are using water meters at least from eleven different suppliers: Sinclair, Kent, Elster Kent, Aqua, Avensys, SPX Spanner, Sensus, Castle, Meinecke and Zenner. Types and diameters of the meters vary but in house connections 15 mm, 20 mm or 25 mm water meters are used commonly. In commercial buildings, public schools, hospitals and so forth meter diameters are usually bigger, up to 100 mm, due to higher demand of water flow. Generally, water meters are made of brass and iron, which have lately caused thefts due to high demand of scrap metal in the country. As a result of that, new plastic meters have been introduced in every reviewed municipality. These are currently being tested in all related inland municipalities while coastal towns, Lüderitz and Swakopmund, have used plastic meters already for a few years due to unfriendly climate conditions to metal meters. According to technical manager of Swakopmund, metal meters’ life expectance is only about two years in coastal area. So far, the results of using plastic meters have been very promising although, in Swakopmund, problems occurred some time ago with Cosmos Meinecke plastic meters and 80 of them had to be sent to the supplier for testing. Meters stopped recording totally after few months use; it is assumed that the reason was too high tenderness to small sand particles going through the meter.

Most of the municipalities do not have complete lists of consumer water meters and usually the given total amounts are only rough estimations. At the moment Windhoek has reported to have altogether 45 000 water meters, Swakopmund 10 000, Omaruru 1 114 and Keetmanshoop 3 154 but Lüderitz and Ondangwa could not provide that information although it is little doubting because the billing system should surely know how many meters exist. According to number of households in Lüderitz, the amount of consumer water meters should be around 3 600 (National Planning Commission 2007, 38). Nevertheless, Lüderitz’s technical department has started a project to import information about replaced or repaired water meters into a simple computer database and after a while the database should contain all the information about water meter types installed, meter readings and the like.

Generally, water meters are installed by technical departments’ plumbers but in Windhoek, installations have been partly outsourced to a private contractor on a two-year contract although some meters are still installed by the Municipality’s staff. In general, water supply cut-offs are made either by technical departments’ plumbers or water meter readers (Keetmanshoop). Commonly, if the monthly consumption is doubt to be abnormal, municipality’s meter reader will notify the technical department. After that, operation of the meter is checked and if the meter is cleaned and starts to operate again it will not be replaced, but if there seems to be a problem it is replaced. If the meter is not operating, due to vandalism (in case of illegal connection whatsoever), the cost of a new meter will be charged from the consumer. When a meter is replaced or repaired, the meter is read one month later and the water consumption is calculated. The bills of previous months are then corrected according to this reference month.

Consumer water meters are read by a group of meter readers usually consisting of 2–5 meter readers excluding Windhoek Municipality, which has many meter readers due to high number of water meters. Normally meter reading is done once in a month manually by writing readings on a notebook and afterwards importing them to a computer system. In Swakopmund, it has been put into consideration that in the future readings could be done by electronic recorders, which are directly through radio frequencies, connected to the computer system. From the related municipalities, Windhoek is the only one, which is already using this system. In some of the municipalities, meter readers have also additional assignments such as calculating water bills (Lüderitz) and bringing them to the consumers (Lüderitz and Omaruru). In Lüderitz and Windhoek, electricity meters are also read by the water meter readers.

4.3.3. Public standpipes and prepaid water meters

Although municipalities provide a high number of physical water connections to plots, still some of the residents are supplied by public standpipes or prepaid water meters. The amount of public standpipes varies due to sizes of the towns; Windhoek, with a relatively big population has about 150 prepaid water meters but Omaruru, with 6 800 residents has only twenty, Ondangwa twenty-five and Lüderitz forty. Keetmanshoop has stopped using prepaid water meters totally. According to the personal communications, every municipality has had problems with the functionality of prepaid meters. In some cases water did not come out from the tap even though a proper token was used and in some cases, instead of using a valid token, for example in Ondangwa car keys and knives could be used as tokens. Nossob and Watermaster prepaid meters have been commonly in use but currently municipalities are making tender notices and searching for new suppliers (Omaruru, The Namibian 7.7.2008). In addition contracts are made by private companies to move the maintenance and support responsibilities outside from the technical departments. For example Windhoek has made a five year contract with a private company to maintain their prepaid water meters and currently Omaruru is having negotiations with TagMeters for three months demonstration period of new type of prepaid water meter. Based to the results, a decision of replacing all 20 standpipes will be made one way or another. Also Ondangwa is relying on TagMeters and a testing period will start in September of 2008.

4.3.4. Water connections

In every municipality, the residential and business water connections are done by the municipalities' water staff by providing the installation of pipes in the vicinity of the plot and water meters. After that, responsibility of house connection installations and internal plumbing moves to the owner of the plot. The fees allocated on water meters vary a lot. Normally, when installing new water meter, consumers must pay a connection fee depending on size of the water meter or purpose of the use (business or residential). However, for instance in Omaruru and Keetmanshoop, have only one fixed fee pointed for new connections. In addition, every municipality has allocated annual basic charges for each meter size likely depending on purpose of the use. Moreover, in case of illegal actions such as illegal connection, bypass of the water meter and sabotage or tempering, municipalities have different offenses allocated to them.

4.3.5. Fire brigades

Firefighting is executed in different ways in each municipality; some do not have a fire brigade at all while the rest have but their compositions and resources differ quite much. Windhoek's Fire Brigade is very professional consisting only of permanent employees and equipments and vehicles used are rather new and modern. Some time ago, Municipality used also volunteers but this practice has been stopped due to insuring problems of the volunteers, which were ordinary citizens.

In Swakopmund, Fire Brigade is under the Community Development Services and considering the size of Swakopmund, Municipality is relying only on two permanent vacancies, fire officer and his assistant. The rest are volunteers, altogether about 25. Most of them are working for the Municipality but some of them are just regular citizens. In the future, it is planned that the Fire Brigade will have more vacancies but it is still under consideration. Generally, the Fire Brigade is very well equipped and new fire station will be built in next year.

There is no fire brigade in Ondangwa. So far, the Technical Department is the body responsible in case a fire occurs. The department has no person specially assigned to fire fighting, but the staff will be involved when a need arises. One staff member of the Technical Department is on standby after hours, and he is the one to be called in problems with water, sewerage and fire.

Keetmanshoop's Fire Brigade is under the Department of Corporate Affairs and Human Resources and consists of one permanent fire officer and three firefighters. For emergencies, Fire Brigade has a reserve of 8–9 volunteer firefighters from the Municipality's staff. In the beginning of 2008, Fire Brigade bought a new fire truck from South Africa and has now better position to carry out its job more effectively and efficiently.

Omaruru does not have a permanent fire brigade but a volunteer-based extinguish unit is under the Technical Department. It consist of ten Municipality workers and the equipments are rather good; Municipality has received some time ago full-equipped fire truck from Sweden as a donation from its partnership Municipality.

4.3.6. Maintenance

In municipalities every operation to the water distribution network is made by the technical departments although in some cases testing and supervising of certain targets have been pointed to other instances such as fire brigades and financial departments (see Table 4.2.). According to the conversations with technical managers, it seems that water meter reading and looking after is appointed in every case to financial departments' water meter readers. Defects are reported monthly to the technical departments and maintenance is done, in case of minor operation such as cleaning the meters, by the meter readers but with major problems, technical departments' plumbers are called for assistance.

Table 4.2. *Municipalities' maintenance responsibilities.*

	Shut valves		Fire hydrants		Water meters	
	Checking	**Maintenance**	**Checking**	**Maintenance**	**Checking**	**Maintenance**
Swakopmund	TD 2 weeks periods	TD	FB Once in a year	TD	FD During reading	TD
Ondangwa	–	TD	–	TD	FD During reading	TD
Lüderitz	TD Once in a month	TD	TD 3 months periods	TD	FD During reading	TD
Keetmanshoop	–	TD	FB Once in a month	TD	FD During reading	TD, FD
Omaruru	–	TD	–	TD	FD During reading	TD

Notes: TD) Technical Department
FD) Financial Department
FB) Fire Brigade
–) Non-existent

In case of shut valves, maintenance routines differ quite much in the surveyed municipalities. In Swakopmund, Technical Department's resources are far better than for example in Keetmanshoop, therefore replacing parts or general maintenance will be put in place faster. The quality of the maintenance is more or less fine, man-holes' cleaning is done immediately on the spot but what comes to the bigger operations, the ignorance of replacing leaking and non-working shut valves, is alarming. In some cases, the same leaking and non-working valves can still exist for many years without any real maintenance done. In Ondangwa, Omaruru and Keetmanshoop, due the ignorant maintenance culture, maintenance is not routine at all, checking and testing is non-existent and replacements and repairs are done only when problems occur.

Fire hydrants are in Keetmanshoop and Swakopmund under the fire brigades administration although technical departments are doing the maintenance. Schedules of testing differ quite much, formerly in Lüderitz, fire hydrants used to be opened once in a month but people started to complain that water is wasted and thus for the time being municipality has moved to more seldom checking routine. In Swakopmund, testing is done only once a year and according to the report made, hydrants are checked and replaced if necessary. Currently in Swakopmund, Technical Department is replacing all underground fire hydrants to visible ones because of easier use and maintenance. In addition, all new areas will be serviced by on-ground fire hydrants but in Keetmanshoop, it has been found out that on-ground fire hydrants are attractive for water theft thus the use of underground fire hydrants remains.

Municipalities' ad-hoc maintenance is done by the technical departments' water teams, which are on standby all the time. However, for instance Keetmanshoop has hired a private guarding company to response emergency calls although the water teams are doing the fieldwork. Usually the residents are very responsible on water issues, when they see abnormalities in the water network; it will be immediately reported to the maintenance.

4.3.7. Development

Government of Namibia has compiled National Development Plans to meet the long-term goals described in Namibian Vision 2030. In 2008, National Development Plan (NDP3) has reached its third edition and it continues being the guideline for the progress of the country. According to NDP3 Volume I and II (2008), it is clear that no extra support is directed for urban development of water infrastructure whereas regional rural water supply and resource management have been promoted. According to NDP3 Volume II (2008, 41–45), the key activities are mainly directed for supplying water for rural villages, improving bulk water infrastructure (NamWater) and quality of water, creating new water supply schemes and transfer responsibility for rural water supply systems to local communities. In addition, NDP3 programs include formulation of Regional Rural Water Supply Development Plans, borehole rehabilitation, upgrading and constructing new dams and constructing area office facilities.

However, as written before, some of the municipalities have concrete plans to replace all the old pipes in the future. Swakopmund has already budgeted replacements for next few years so that every year some part of the town is renewed by new uPVC pipes. Windhoek has been replacing old pipes already for years. Omaruru does not have yet a renewing plan of the pipes but according to the technical manager and town treasurer, it will be put into consideration and budgeted for next financial years. According to the budgets, Lüderitz has been putting a lot of effort to replace old pipes in last two years. In 2006, the budget for network maintenance and development projects was N$ 1 200 000 while in Keetmanshoop it was only N$ 250 000. More information about budgets can be obtained from Chapter 4.5.

Municipalities of Swakopmund, Omaruru and Keetmanshoop have been lately interested in starting their own remote zone metering practices. With remotely controlled electronic water meters at the inlet of each suburb, municipalities could watch water flowing rates from each area in real time. From water pressure graphs and pressure peaks in the network, maintenance team can immediately see if the water network is leaking and for statistical purposes, consumptions per area can be easily exported from the system. At the moment only NamWater can provide such information (although only from their own meters) for the municipalities but for instance in Keetmanshoop the data is not shared very eagerly due to "silent" cooperation between both instances. However, Swakopmund is having very good mutual understanding and cooperation with NamWater and information is distributed widely.

4.4. Unaccounted-for water

Much of the water produced at municipal treatment plants or purchased from bulk water suppliers never reaches its intended final destination. Unaccounted-for water (UFW) is calculated as being the difference between the quantity of water purchased/produced and total water sales. (Holtzhausen 2003, 25; Twort, Ratnayaka & Brandt 2000, 24–26) See Table 4.3. for average unaccounted-for water on yearly basis in each municipality.

Table 4.3. *Total consumptions and UFW rate in each municipality in 2007–2008*

	Total consumption per annum (m^3)	**Total volume of billed water per annum (m^3)**	**Unaccounted-for water (%)**
Windhoek	22 000 000	19 800 000	10
Swakopmund	3 500 000[1]	2 975 00	14–17
Ondangwa	654 000[1]	unknown	unknown
Lüderitz	1 100 000[1]	unknown	unknown
Keetmanshoop	1 600 000[1]	1 000 000	37,5
Omaruru	720 000	564 000	21,7
Kangasala	1 934 334[2]	1 661 592	14,1
Lempäälä	1 493 676[2]	1 224 814	17–18

Sources: 1) NamWater's records
2) Municipalities' bookkeeping

According to Twort, Ratnayaka & Brandt (2000, 655) with some alterations, the chief components of non-revenue water can be divided into the following:

1. *Unmeasured legitimate use*, which includes
    - legal connections with no payment requirements (connection recorded), for example public standpipes
    - legal connections but consumption is not billed (connection not recorded)
    - demands for fire-fighting (usage could be measured)
    - street cleaning and sewer flushing (usage could be measured)
    - old or unmaintained water meters (equipment error)
    - incorrectly read meters (employee error)
    - incorrect billings (employee error)
    - daily plumbing activities (cannot be measured accurately)
2. *Losses and non-legitimate uses*, which include
    - leakage from distribution network
    - leakage and overflows from service reservoirs or water towers
    - illegal connections, meter-tampering or by-passing
    - unreported third party damage to pipe network

According to the conversations, each municipality has pointed out and emphasized different reasons for the water losses but more or less, they are the same in each municipality. In general, unmeasured legitimate use was not considered as a big issue but non-legitimate such as leakage and illegal use was proven noteworthy.

4.4.1. Unmeasured legitimate use

In Namibia, legal connections with no payment do not really exist. Mostly all public standpipes are installed with prepaid water meter thus; consumers have to use a token in order to get water. Due that, water usage is recorded and billed in normal situations. Nevertheless, as stated before, all related municipalities have had problems with prepaid meters and not all flown water is recorded and sold. These circumstances can make public standpipes rather big consumers and a remarkable source of water losses.

Usually Municipality properties such as parks, stadiums and others are legally connected to the water network but not always irrigation water has been measured. It cannot be “billed” from residents but it should be considered as expenditure in municipalities’ budgets and bookkeeping. However, every municipality assured that every drop is recorded but whereas in Keetmanshoop, own water usage has not been measured very well (see Chapter 5.4.) and that has caused partially its high UFW rate.

Measuring the water usage for firefighting is complicated due the high investment value of installing fire hydrants with water meters. Some of the municipalities have few of these measuring fire hydrants but normally they are installed with non-measuring units. Depending on the case, used equipments and experience of the fire fighters, the maximum theoretical amount of water used in a single 70 m^2 or 189 m^3 volume room fire, is 0,110 m^3 (Wikipedia 2008: “Firefighting”). Circumstances are different in every situation thus accurate consumption cannot be given and the maximum consumption is not a constant. However, together with fire hydrant testing and few fires in a month, total wastage on a yearly basis can arise noteworthy. In case that municipality has its own water sources, such as boreholes or semi-treated water supply, fire fighting and street cleaning can be executed by these additional water sources. For example in Keetmanshoop, it gives an advantage to use “free” water, which is not indicated anywhere (although it should). Water network flushes has to be done with treated water but sewerage can be flushed, for instance, with semi-purified water. It is unknown how much water is used at the time nor does anyone record the consumption but it is sure that network flushes are not done very often. For example, according to the former technical manager, pressure tests for new developments have not ever been done in Keetmanshoop.

Old and unmaintained water meters can be a problem, due to fact that they are not recording properly resulting that some of the consumption is not billed. However, because municipalities are using mostly the same meter types, it seems that at least residential water meters are working somehow accurately. Equipment tests made in Keetmanshoop support this statement, where water meters were tested in general. According to it, it seems that residential water meters are generally quite accurate (-1,8%, over-recording) with few exceptions. Naturally, this argument is too generalizing and it should not be considered as a fact in each municipality.

Incorrect reading of water meters is generally quite difficult due to systematic measuring practices in each municipality where history of previous consumptions can be obtained from the system. If a meter reader makes a mistake, it is usually noticed in the office when comparison between previous and new meter reading has been made. If the difference is big, it should alert the officer. The same applies on billing but if a mistake happens, usually customer will complain about it and problem will be fixed. However, head of the Technical Department in Swakopmund has been concerned about municipality's internal consumption calculation methods. After their computer system was changed, unaccounted-for water has increased. Regardless, these kinds of problems have not been reported from other municipalities.

Daily plumbing activities are very difficult to be measured but fortunately, the amount is quite small. It consists of daily routines to pipe network such as meter installations, cleaning and pipe replacing.

4.4.2. Losses and non-legitimate use

Generally, it is reported that the biggest losses are created by leakage, especially in the old town and rural areas, where old pipes are located. Rural areas are big problem especially in some municipalities where have been encountered heavy water losses due to fact that it takes a lot of time that the pipe burst is found out and reported to the maintenance team. When the maintenance team arrives on the site, thousands of liters have already been wasted. Similar water losses have also been experienced in town areas due to non-operational or inexistent valves in the critical spots of the distribution network hence the broken pipeline cannot be shut down. However, pipes are not the only parts of the network which causes leakage, moreover old shut valves and fire hydrants tends to leak but not in terms of a disaster or a huge loss. Overflows or leakages from the reservoirs have not been reported but vandalism yes. For example in Lüderitz, in 2008, piece of pipe was stolen from the main reservoir's outlet inflicting reservoir to release all water to the town causing damage to the properties and water shortage. In addition, the same reservoir was used as a public toilet and a trash bin by the informal residents.

Second most addressed problem was illegal use and connections to the water distribution network. All the municipalities were worried about illegal connections and have had cases where a consumer had to be sentenced to pay a fine. The biggest problem is that illegal connections are hard to find and mostly municipalities needs informers to catch the criminals. However, if one is caught, penalties are quite high. In Lüderitz, Keetmanshoop and Ondangwa the fines of illegal connections are N$ 2 000 and in Omaruru N$ 1 000 for first offence. However, Swakopmund differs from the majority only with N$ 500 penalty. These fines are rather considerable and usually the criminal does not have money to pay it therefore the imposed penalties are not very practical. Usually, the illegal operations towards the water distribution network are directed on the water meters, only seldom consumers make illegal bypasses or connections directly to the network itself. In most cases, water meters are taken out so that water can flow freely out of the network, and before the water meter reader comes, meter is installed back to its original place. In other cases, water meters are taken out and installed other way round on the spot in hope that meters would start to record backwards. Fortunately, this is only a feature of some meter types and the newer types cannot be installed other way round because they are installed with non-return valves, thus water cannot get through.

All these methods of wasting water accumulate a lack proper management. Management is in the position of giving initiatives and the first practical moves, and if these are not done, plans and actions are cancelled or delayed. Especially Omaruru and Keetmanshoop have had problems with administration due to lack of key persons in the technical departments and generally in the municipalities. Omaruru could finally fill the position of technical manager after waiting for three years and Keetmanshoop is currently missing the CEO, the Strategic Executive for Technical Services and the Chief Technician. Lack of management has caused delays and ignorance on water services so that not all maintenance has been done, developments have been put aside and so forth.

4.5. Financial aspects

Due to Local Authorization Act (1992, 31.1.c), local authorities can independently decide their water fees. Yet each local authority has to submit its water charges as well as any other fees or charges to the Ministry of Regional and Local Government and Housing for publication in the official Government Gazette (2003). Usually, this procedure is just a formality, and only rarely MRLGH want to discuss the level of the proposed charge with a local authority. Only after the fee or charge has been published in the Government Gazette, then local authority can start using it. (Pietilä 2005, 57)

Payment of water is based on the volume of water used or a fixed charge. In most cases, local authorities are using an increasing block tariff but elsewhere, the same unit price is charged for water regardless of the amount used. (Pietilä 2005, 57). According to Holtzhausen (2003, 43), one third of the local authorities use an increasing block tariff with clear steps. In this case, Windhoek, Lüderitz, Swakopmund and Omaruru are using the system. Some of the towns have also monthly charges, depending on the meter’s size, for renting the municipality-owned water meters. Tariffs for water differ quite much between the municipalities (see Table 4.4).

Table 4.4. *Water tariffs in the financial year 2007–2008 (Excluding VAT 15%)*

	Residential		**Industrial & Commercial**	
	m^3/month	**N$/$m^3$**	**m^3/month**	**N$/$m^3$**
Windhoek	0–6	6,27	Per m^3	11,07
	6–45	10,43		
	45–	19,21		
Swakopmund	0–8	5,64[1]	Per m^3	6,25
	9–30	8,75		
	31–60	11,30		
	6–	16,30		
Ondangwa	Per m^3	9,81	Per m^3	9,81
Lüderitz	0–15	8,11	0–500	14,58
	16–30	10,72	500–10000	16,27
	31–60	14,10	10000–	17,96
	61–	21,50		
Keetmanshoop	Per m^3	8,60	Per m^3	8,60
Omaruru	1–99	3,26	Per m^3	3,37
	100–200	4,53		
	201–	10,80		

Notes: 1) Basic tariff + meter rent according to the diameter per month

Budgeting is handled differently in each municipality so that same information could not be extracted very easily. For example, Lüderitz is giving prepaid sales separately while Omaruru and Swakopmund have included them into water sales. Keetmanshoop does not give any indication how their revenue has been divided into sub-categories, the only income is reported to be water sales and sundries. However, in Lüderitz, all water related information could be extracted from the budget and revenue is logically divided into water sales, basic charges, prepaid sales, penalties and so forth. Differences between technical departments' budgets for water vote can be seen from Table 4.5. Purposely, not all sub-categories are shown and Windhoek Municipality has been left out from the comparison due to disparate size.

Table 4.5. *Operating budgets in municipalities for water vote 2008–2009*

	Swakopmund	**Ondangwa**	**Lüderitz**	**Keetmanshoop**	**Omaruru**
INCOME					
Water sales	28 774 700	7 600 000	12 450 000	10 970 000	2 562 071
Prepaid sales	–	250 000	475 000	–	–
Basic charges	422 000	–	700 000	–	–
Connections	785 000	182 000	70 000	–	4 400
Other	108 420	1 000	776 000	12 000	500
TOTAL	**30 090 120**	**8 033 000**	**14 471 000**	**11 982 000**	**2 566 971**
EXPEDINTURE					
Water purchases	18 250 000	5 750 000	8 300 000	10 200 000	–
Maintenance[1]	520 000	330 000	500 000	300 000	35 000
Developments[2]	150 000	–	–	200 000	–
TOTAL	**25 714 580**	**6 856 562**	**11 161 851**	**11 612 170**	**830 249**
SURPLUS/ (DEFICIT)	**4 375 540**	**1 176 438**	**3 309 148**	**369 830**	**1 736 722**

Notes:
1) Only routine and ad-hoc maintenance for water network
2) Capital projects for developing water network (old pipe replacing and new development areas)
-) Not indicated in the budget

The biggest budgets for network maintenance and development seem to be in Swakopmund and Lüderitz, which indicates serious contributions to water network affairs. For past three years Lüderitz's budget for network maintenance have been N$ 2 500 000 while in Keetmanshoop only half of it. Anyway, Omaruru, with an enormously small contribution, and Keetmanshoop, with current difficult situation (see Chapter 5), would really need more efforts on maintenance and development issues. Whereas, Swakopmund together with Lüderitz, seem to be financially the most well managing municipalities, with a big surplus compared to the others.

5. ANALYSIS ON KEETMANSHOOP

5.1. General information

Before the arrival of Europeans, the area was known as #Nu#Goases, which means "Fountain of Black Mud" and indicated the presence of a spring in the area. In 1860 the Rhenish Missionary Society founded a mission there to spread their faith to the local *Nama*. The first missionary, Johann Georg Schröder, arrived in Keetmanshoop on April 14, 1866, which is now marked as the founding date of Keetmanshoop. The mission station was named after the German trader Johann Keetman who supported the mission financially, but never actually visited the place himself. (Municipality of Keetmanshoop 2008a)

Town is situated approximately 500 km south from Windhoek and only 400 km from the borders of South Africa. It is a town surrounded by mountain and dry areas of sheep grazing; it has beautiful scenes for tourists. Keetmanshoop Constituency (both Urban and Rural) is a host to approximately 22 000 according to the 2001 Population and Housing Census, Karas Region (2004, 7–8). This is about 36% of the total population of the Karas region. Keetmanshoop is the centre for the regional government, Karas and Regional Council that looks after the villages and settlements in the region. There are proper schools, a state hospital, a good telecommunication infrastructure, a well-maintained road network as well as a rail network from Karasburg through to Windhoek. (PLDDSI 2008). Map of Keetmanshoop is presented in Appendix 1 and some photos in Appendix 9.

5.1.1. Population development

According to 2001 Population and Housing Census, Karas Region (2004, 3), the population of Keetmanshoop Urban was 15 777. Currently the population is unknown but it is estimated to be around 16 800. Due to lack of knowledge and information in the Municipality, it has been very difficult to get an overall description of the structure of the population and development in the area. However, National Planning Commission could provide some useful unpublished information on Table 5.1., which was gathered during the Census project in 2004.

Table 5.1. *Estimated populations in each suburb in 2008 according to National Planning Commission 2004*

Suburb	Population
Town	1 116
Westdene	1 453
Nordhoek	1 874
Krönlein	3 100
Tseiblaagte	8 234
Total	**15 777**
With surroundings	**22 176**

94% of all households in Karas Region have access to safe water but in the urban areas of Keetmanshoop, the percentage is 99. Practically all plots in Keetmanshoop have a water connection and sewerage due to servicing policy of the Municipality.

5.1.2. Municipality's organization

According to Local Authorization Act (1992, Schedule 1, 96) municipality has been declared as "part 2 municipality" and due to that it has a Town Council, consisting of seven council members. The chairperson of the Council is the mayor of the Municipality and he has a deputy from the same group. Three members are part of a management committee and the last two are ordinary members. The Council is responsible for the welfare of its residents in terms of: basic services such as water, electricity, sanitation/sewerage, traffic and fire brigade, housing and road networks but other services such as education and hospital are still in the hands of the central government. The decentralization program is not yet fully implemented in the whole country.

Keetmanshoop Municipality has a staff of 128 people. It is divided into CEO's office and three departments, which are Department of Corporate Affairs and Human Resources (CAHR), Department of Finance and Economic Development (FED) and Department of Infrastructure and Technical Services (ITS). Currently, Municipality's organization is under development and alterations have been made to the old organizational chart but it has not yet been approved by the Town Council. However, it is expected that the new plan will replace the former one in September 2008. See Chart 5.1 for administrative level of the Municipality.

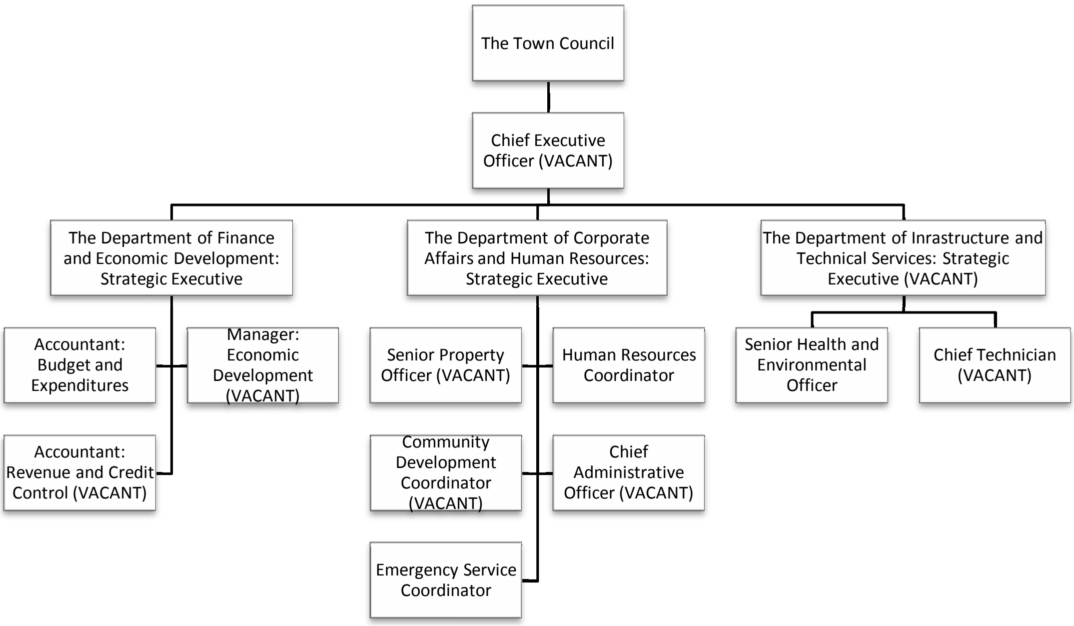


Chart 5.1. *Administrative level's organizational chart*

Due to lately alterations in the staff, eleven posts were vacant during the research period July–August 2008. Although the number is quite low, it has a significant affection to the workload of the staff and managing of the Municipality. The posts which are vacant, are mostly the posts of the administrative level officers such as Chief Executive Officer, Strategic Executive of ITS, Chief Technician (ITS), Manager of Economic Development (FED), Accountant (FED), Chief Administrative Officer (CAHR) and Community Development Coordinator (CAHR). Due to that, Municipality has been busy of trying to employ new people on the vacancies but the results have not yet been sufficient.

Because of the nature of the research, Department of Infrastructure and Technical Services will be introduced as a whole. The Department has a rather wide variety of responsibilities: water distribution, sewerage and wastewater ponds, street maintenance and maintenance of sport grounds, swimming pools, cemeteries and parks. Municipality does not employ a town planner but has a long-term and reliable partnership with a private town planning company Stubenrauch Planning Consultant from Windhoek. Technical Department (ITS) consists of 74 staff members (see Chart 5.2., other departments' organizational charts in Appendix 2), which does not include fire brigade and water meter readers. The Fire Brigade is under the CAHR's Emergency Services unit and water meter readers under FED. The Fire Brigade has four permanent members, one officer and three firefighters. In case of emergency, Fire Brigade has a reserve of 8–9 volunteers, who are Municipality's staff due to insurance conditions.

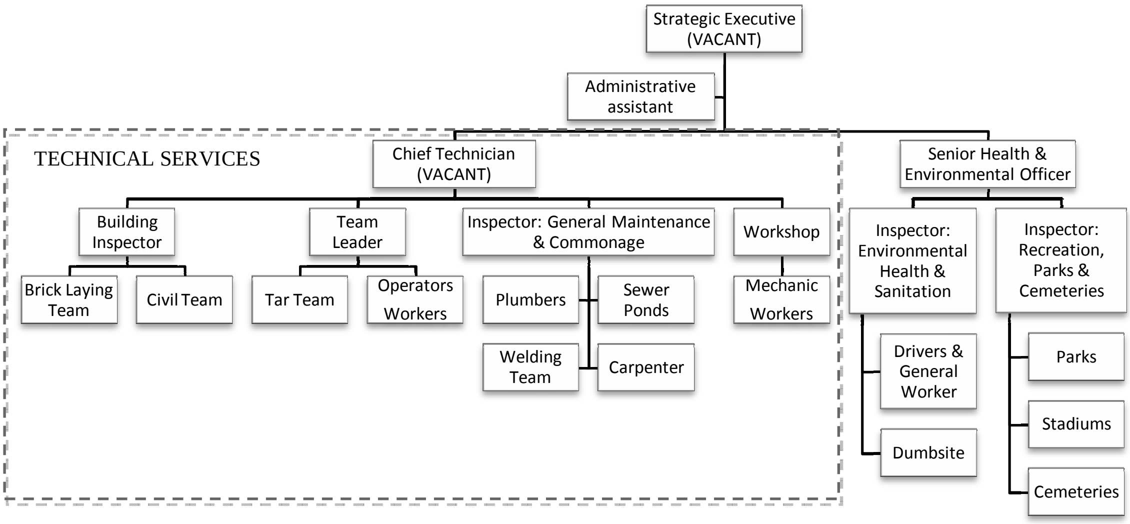


Chart 5.2. *Department of Infrastructure and Technical Services (ITS), draft 22.8.2008*

Municipality staff's educational background is quite low. Only four top administrators have a degree (Bachelor) from a university (foreign), and the rest of the officers (middle managers) have only professional education after grade 12 (12th year in school). So-called "skilled" workers such as data processors and lower clerks do not have any other education than basic school, up to grade 12. Unskilled and semi-skilled general workers, drivers and plumbers have usually stopped school earlier and got some kind practical training or not education at all. These general workers take almost half of the total amount employees.

In accordance with Local Authorities Act (2001, 39), municipalities have power to allocate bursaries and loans for educational purposes. According to Strategic Executive of CAHR, Municipality offers further training, part-time courses and bursaries for its staff but lately it has become a little problematic due to fact that when the new knowledge has been obtained, staff tends to resign and seek new working places (from private companies) for higher salaries. However, according to few general workers, it seems that advanced training courses do not reach them and mostly the possibilities are offered only to the managing level employees. Regardless, Municipality has had troubling situations where general workers, who have been working as a "plumbers", have taken courses of plumbing; they started to require the salary of "a professional plumbers" and higher positions in the organization. In real terms, if a person in a lesser developed municipality has an education of a professional plumber he would get at least a vacancy of the Chief Technician, which is the next from the Strategic Executive.

5.2. Use of water

5.2.1. Water sources

Keetmanshoop's main water source is Naute Dam some 50 km way in the south. Water is purified and chlorinated in a treatment plant by the dam, pumped to the reservoirs on top of Oxpass hill, near Keetmanshoop. Water is chlorinated again before it enters the reservoirs and flows through all three reservoirs before let to the town. NamWater operates water supplying until a water meter between NamWater's reservoirs and Municipality's reservoirs. See Appendix 9 for photos.

Municipality uses also three boreholes for its own needs. One is located in the center of the town and two others in the eastern part of the town (Ileni and Tseiblaagte). Usually water from the boreholes has been used for filling fire brigade's tankers, maintenance of the street and irrigating Tseiblaagte stadium's grass but nowadays also for supplying water to fish farms and a greenhouse in Tseiblaagte. There is also "illegal" use of boreholes (Tseiblaagte) but it seems that nobody cares because the water level is only around six meters below the ground level and sometimes the pressure is so high that water comes on the ground itself forming springs around the pumps. In addition, the taps are easily to be opened hence water stealing is very easy. See the Ileni borehole in Photo 5.1.

Photo 5.1. *Ileni borehole, water is forming springs around the pump. White ground material is salt. © Risto Seppänen 2008*

At the moment boreholes are not connected to the water distribution network but in the beginning of 2008, a pipeline was built to bring water from the town borehole to caravan park, public swimming pool and main stadiums in Westdene but the project was stopped in March 2008 due to insufficient supply pressure to the farthest parts of the pipeline. The basic idea was to pump water straight to the caravan park, swimming pool and finally to the old reservoir on Oxpass hill. From there, irrigation water was supplied through another pipe to the stadiums but it was found out that the pressure was not sufficient to be used on irrigation purposes. To make the situation even worse, shut valve was stolen from the outlet of the reservoir, making the reservoir unusable.

5.2.2. Water users

In order to understand the issues and problems related to the production and distribution of water for consumption, it is important to know the vocabulary used by water-management professionals. Water supplied for residential use, including personal hygiene, laundry and lawn watering is called domestic consumption. To this consumption is often added the water supplied to small business such as stores and shops. Total consumption per person or total consumption per capita, is the ratio of the daily volume of water produced to the number of inhabitants. This consumption is often expressed in liters per person per day. (Brière 1999, 47–48)

Keetmanshoop’s total water consumption is on average 1 600 000 m^3 per annum according to the NamWater’s billing. The figure does not include borehole water but the amount is marginal compared to NamWater’s supply. However almost third of the total consumption is wasted and counted as unaccounted-for water. The rest, approximately 1 000 000 m^3 per annum is divided for the five suburbs in the town and surrounding areas, and can be called as “total billed consumption”. See Figure 5.1. for total billed consumption divided to areas.

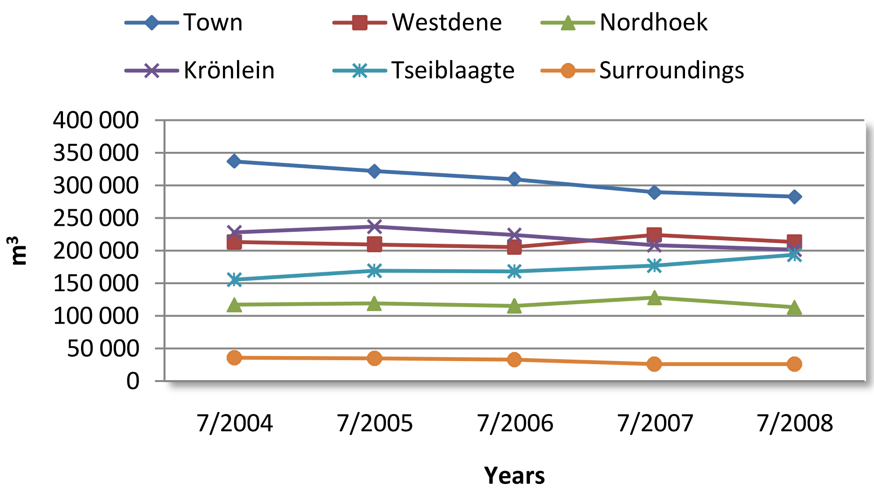


Figure 5.1. *Municipality’s total billed consumption divided to areas*

The biggest consumer is Krönlein hospital with annual 60 000 m^3 consumption. High schools with hostels conquer the second place, accompanied by police station, prison, military base and the biggest hotels and lodges. See the biggest consumers from Appendix 3. These industrial and commercial (non-domestic) services are taking 35% of the total billed consumption in the town. Residential (domestic) consumptions differ quite much when suburbs of the town are compared together. In Westdene, which is the richest part of the town, water consumption is very high because residents are using water for gardening and such pleasures as swimming pools and so on. Average consumption per capita is almost seven and half times bigger than in Tseiblaagte, which is the suburb for informal settlement and the poor people of the town (see Table 5.2).

Table 5.2. *Domestic and non-domestic consumptions per area in period of 1.7.2007–30.6.2008*

	Domestic consumption (m^3)	**Non-domestic consumption (m^3)**	**Population**	**Domestic consumption per capita (l/d)**
Town	106 726	175 846	1 116	264
Westdene	199 287	14 008	1 453	379
Nordhoek	100 036	13 325	1 874	147
Krönlein	111 403	90 315	3 100	99
Tseiblaagte	151 888	41 515	8 234	51

Per capita consumption in Town area is misleading due to fact that populations are only estimations and some of the non-domestic consumption has been classified as residential use. Problematic presentation of non-domestic consumption in the meter reading books has caused this inaccuracy. Significantly high non-domestic consumption in Krönlein can be explained by the schools and hospital's existence in the area and relatively high non-domestic consumption in Tseiblaagte likewise by many schools and youth hostels situated in the area.

5.3. Water network management

5.3.1. Water network infrastructure

The history of Keetmanshoop's water distribution network is unclear but it is known and proved that the main pipe material has been asbestos cement (AC) for decades. Some cast-iron pipes have been found and replaced through the years but amounts have been very few. Typically, house connections were made by galvanized steel pipes until 1980s when polyethylene (PE) pipes were introduced. First ten years both galvanized pipes and PE were used equally but from the beginning of 1990s the only used pipe material was PE. UPVC have been introduced only few years ago. In 2003, Municipality bought the first ten 160 mm diameter uPVC pipes and smaller diameter pipes followed in the next year. Nevertheless, asbestos cement pipes have been used widely until 2005 and still many AC pipes can be found from the Municipality's stores (see Photo 5.2.). Currently the most used pipe material for mains is 160 mm uPVC. What comes to the house connections and small diameter lines, 20*25 mm polyethylene pipe is still the most used one with 1,6 km usage per year. See Appendix 4 for more information of the used pipe materials. Most used pressure class for uPVC pipes is 9 but in addition, some CL6 pipes (90 mm) can be found from the stores. Used PE has been found out to be CL12.

Photo 5.2. *Asbestos cement pipes and joint pieces at Municipality Stores. © Risto Seppänen 2008*

Based on the town layout, municipality's water distribution network is approximately 150 km long. In the most parts of the town, it incorporates loops, which means that water can reach its destination by different routes. The network is based on gravity, and booster pumps are not used except in the supply line to the airport. Town is under one pressure zone, which is controlled by the Municipality's reservoirs in two locations, in the north near the golf course and on the Oxpass hill west from Westdene. However, town can be divided into different zones by closing critical shut valves at the borders of each suburb but according to the retired plumber, Karl Swartbooi, these shut valves have been open as long as he remembers, at least for 30 years.

The main reservoir (volume of 70 m^3, built in 1960) on the Oxpass hill next to NamWater's reservoirs supplies mainly the nearby areas: Westdene, Nordhoek and Town. There is also another reservoir (volume of 70 m^3, built in 1940) on the hill but it has not been use since 1959. The reservoirs (200 m^3, built in 1960s and 4*50 m^3, build time unknown) near the golf course in Donkiedraie supports primarily Nordhoek, Krönlein and Tseiblaagte although the smaller four have not been in use for decades. In addition, in the center of the town, are two old reservoirs (140 m^3 and 40 m^3), which have been built in 1925 but have not been in use since 1950s.

In general, these old reservoirs are in rather bad shape. Reservoirs on the hill in the Town are totally ruined and unusable for storing treated water. The surroundings of the reservoirs are full of garbage, broken glass and even animal carcasses. Moreover, reservoirs are not covered and structures of the reservoirs are fragile and crumbled thus very serious renovations have be to put in place if to make these reservoirs watertight and useable for storing purified water. The old reservoir on Oxpass hill was in use in the beginning of this year for a short period due to borehole water using practice. It seems that reservoir is useable although it is exposed to contamination due to insufficient covering. The condition of four small reservoirs at Donkiedraie is unknown but they have not been in use for decades thus serious investigations must be put in place before letting water in.

As written before, layout of water distribution network is relatively well up-to-date. During the PLDDSI project, two Finnish and two Namibian students mapped the network in 2007, using old plans and manually locating hidden valves and fire hydrants from the ground. Some adjustments have been made also during this research and at the moment the layout is giving quite an accurate picture of the network. In addition, some detailed maps were compiled of the reservoir areas to give better idea of the complex network to new workers thus; the “silent” information would not fade away together with the old plumbers. While doing the mapping survey it was found out that the plumbers and general workers (maintenance teams) did not have any maps with themselves. When copies were given, it became clear that they did not really know how to read them, and rather studying it, they put them aside. This reveals a lack in the basic knowledge of the workers.

5.3.2. Consumer water meters and public standpipes

Altogether, there are 3 514 water meters in the Municipality. Currently the only suppliers for residential meters are Kent and Sensus but still some old Zenner, Castle, Meinecke and Aqua meters can be found from the consumers (see Appendix 5 for identification). Diameters of the meters vary but 15 mm and 20 mm diameter water meters are used commonly. For industrial and high demand purposes, bigger diameters are used from 25 mm up to 100 mm (Zenner, Avensys, SPX Spanner and Kent). In general, quite high amount of water meters are replaced in a year. According to logbooks in the Municipality’s stores, 299 new meters were replaced (with Kent 15 mm or 20 mm) or installed during a period of one year, between 2006 and 2007.

As stated earlier, municipalities have been encountering problems especially with metal water meters due to attraction for thefts; this has been also a problem in Keetmanshoop.

As a result of that, new Sensus plastic meters were introduced and at the moment when this research was made, eight of existing twenty were in use. Municipality is waiting eagerly the results of this practice thus these plastic meters are only few percent expensive than normal metal meters and the metering unit is changeable so it should cut expenditure because not always the meter has to be replaced totally, only the metering unit.

During this research, a test survey was made to the water meters in the Municipality. The basic idea was to test each type of meter to figure out how accurately they are recording. The tests were carried out with Municipality's staff that willingly helped on the measurements. The procedure was very simple, testers picked randomly a residential or commercial building, a five-liter bucket was filled from the tap and it was made sure that no other water flow was going on in the residence during the measurement. Before and after the filling, readings were taken from the water meter so that difference could be calculated afterwards. This difference showed how accurately the meter was recording and usually meters were quite correct. Especially most of the Kent 15 mm meters were proved to be reliable with 0,9 % accuracy and new Sensus plastic meters are promising with -0,3 % (over-recording) accuracy although only five of them were tested. In general, tests were made too few to show the real situation but total average accuracy was -1,8 %, which indicates that overall meters are recording too much thus residents' complaints are closely argued. See the list of tested meters and description of the procedure in Appendix 6.

Water meter reading has been taken care of FED's meter readers. In 2008, there were four meter readers and the meters were read once in a month in such a way that the same person did not read the meters always in the same area. Readers read the meters in rotation so that when a reader has read the meters in a certain area, next month he will read a different area and a month later again a different area. After four months, he will be again in the first area. Water is billed once a month and the bills are delivered to residents' private bags by FED's data processors. In a case that resident does not have a P.O. Box, bill is delivered directly to his/her house by Municipality's temporary workers. When the bill is not paid in time, meter readers cuts the water connection from the water meter by putting a block in the joint (see Photo 5.3. for typical water meter connection). The block is relatively easy to put in place and taken away if one has proper tools thus some consumers have opened their connection illegally. When it is notified, plumbers will cut the supply from underground valve near the connection to the main pipeline. This valve cannot be opened without special tools.

Photo 5.3. *Typical residential water meter connection (Kent 15 mm). When meter is blocked, a "coin" is put in the joint one or other end of the meter. Red color is marking the place of the block and green color a situation when block has been taken away.*

Keetmanshoop policy is to build water supply and sewer lines in informal settlement areas. 99% of the residents have a water supply in their plot and due to that; public standpipes are not required anymore. Nevertheless, Nossob prepaid water meters were introduced some years ago but they failed to operate, however, they still exist on the spots. According to the staff of the Municipality, prepaid water meters are not going to be used in the future due to bad experiences and a little need.

5.3.3. Water connections

Water connections are made by Municipality's plumbers by providing the supply pipe in the compound. As well as in other municipalities, Keetmanshoop Municipality's responsibility extends until the consumer water meter, after that responsibility moves to the owner of the plot. In case of a new connection consumer must pay connection fee of N$ 150 (2007–2008), which is equal for commercial and non-commercial use.

5.3.4. Maintenance

Municipality has hired a private company to take care of emergency calls although the maintenance is done by four water teams, which are combinations of general workers and plumbers from different sub-sections of ITS. At the time when this research was done, average amount of emergency calls, concerning leakage and pipe bursts, in the night were four. That indicates, together with water teams' huge amount of overtime working hours, a significant amount of pipe bursts in sewerage and water distribution network on one-week periods. In every month, water teams encounter few very big pipe bursts but minor leaks are reported and fixed almost every day.

Usually pipes are not more than one meter under the ground level thus leaks are notified fast but if the case is outside of the town, then notifying can take time. For example, during the research period, one minor leak was found from the Oxpass hill and it was proved active at least for few months. In general, when pipeline is reported to be leaking, a water team will be sent to realize the situation. After a quick check, shut valves will be closed in critical locations to isolate the broken pipe in order that water flow can be stopped in the leaking pipeline. After that, surrounding soil material will be removed and the pipeline revealed. If the leak is minor with small burst, it is usually fixed by a waterproof tighten but in case that pipe has broken horizontally with a long crack, the whole piece of pipe has to be replaced. Usually, in case of asbestos cement pipe, three pieces have to be replaced because of the longer length of the replacing pipes (uPVC). AC pipes are always four meters long and it is not wise or cost-efficient to cut six-meter uPVC pipes to smaller pieces. Currently, the pipeline network is a mixture of asbestos cement and uPVC pipes, which is not an ideal situation. When only a part of the pipeline is replaced by new material, it is inevitable that pipe will burst again in some other point. See Photo 5.4. for visualizing pipe replacing in general.

Photo 5.4. *Big pipe burst in the suburb of Nordhoek. In this case, plumbers had to install an extra shut valve (under the first plumber) to isolate the pipeline because the existing network shut valve did not operate. The whole fixing operation took almost one day and half. © Risto Seppänen 2008*

The Fire Brigade is responsible for checking fire hydrants on every one-month cycle. This practice is done based on experience and map checking to figure out that none of the fire hydrants have left out without checking. What comes to the shut valves, no one is checking them in a regular basis. In case that Fire Brigade or some other instance notice defective shut valves, it will be reported to the ITS but generally checking and maintenance is non-existent. Moreover, some of these valves are underground and cannot be seen. The regular check-up of the fire hydrants is done in this way: Fire hydrants are opened and closed slowly to counteract the sudden change of water pressure for the pipe not to burst. If fault is detected, it will be reported to Municipality's technical officer for maintenance. Shut valves are checked in similar way as fire hydrants, and if there is any problem detected, it will be reported likewise to the ITS's officer.

Basic maintenance such as cleaning of water meters is done by the meter readers but when it comes to replacing of the meters or general plumbing, ITS's plumbers will do the job if requested. Kent type meters are usually changed on the spot to new ones because repairing is not cost-efficient but other types can be cleaned and used again. Non-functioning water meters are dumped in the Municipality's stores and sold to scrap metal companies. Usually, during the meter reading procedure if a defect is found out, it will be reported (after few bureaucratic steps) to the Municipality Stores. From there, plumbers will get the replacing meter and install it on the spot. Generally, this procedure can take from one day to one week depending on the workload of the plumbers. Meter cleaning is usually done after meter readings, usually in the next day, because it is unpractical to carry heavy tools while gathering readings.

5.3.5. Spare parts and stores

Spare parts are provided from Municipality Stores, which is administrated by FED's Stores Controller together with Stores Clerk and general workers. As stated before, obtaining materials from the Stores can be quite bureaucratic. Bookkeeping is based on special paper notes and folders, which makes the system rather slow and inefficient. However, the system seems to work and everything is nicely organized in an office and a warehouse. Smaller parts such as water meters, fittings, special pipe pieces and joints are stored in the warehouse but for instance pipes and big shut valves are piled outside, which make them vulnerable for climate conditions. For example, uPVC is tender for ultraviolet light making it to degrade. The effect increases with temperature so that the pipes should not be exposed to sunlight in hot climates for more than a day or two (Twort, Ratnayaka & Brandt 2000, 581). Stores provide also petrol for Municipality vehicles and place where to keep other equipments and materials. Municipality has also garages for vehicle repairing and plumbing in Town.

Materials for water and sewerage networks are mainly provided by four different suppliers: Sinclair Services, Valco Pipes, Petzetakis and Obeco. According to the Stores

Controller and quotations, pricing competition is rather broad and all suppliers are used equally although, some companies have been allocated only to certain targets such as Obeco for water meters (both Sensus and Kent) and Petzetakis for developing projects. All stated companies are operating from Windhoek but materials are coming usually abroad, for instance South Africa.

5.3.6. Development

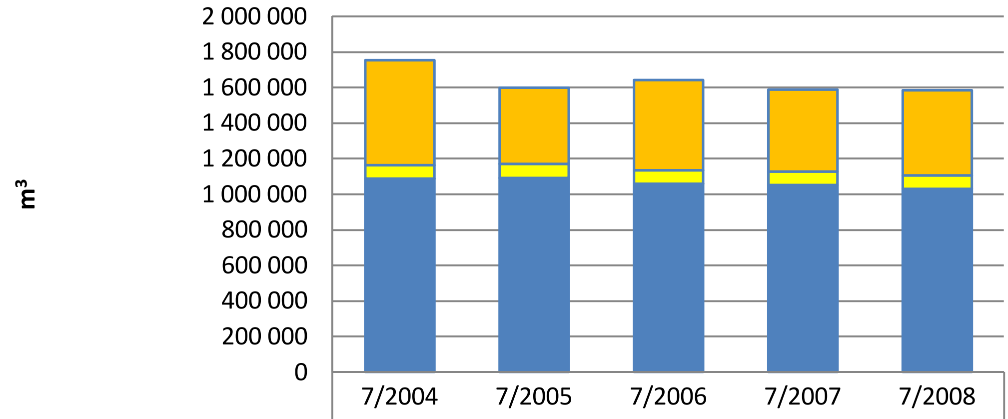
According to the Regional Development Plan of Karas Region (2001), the Regional Council does not seem to pay any attention to the old water networks in its area. All resources are provided for new developments such as servicing new plots or figuring out new water sources in the region. The development of old infrastructure has been appointed on the shoulders of the municipalities and due that, Keetmanshoop is in a rather difficult situation because of the low financial situation. According to the Deputy Director of MRLGHRD, Ministry is aware of these problems but they are not in the position to give initiatives, professional and financial support directly. Ministry provides funds and resources for the Regional Councils and funds are allocated through them to the municipalities. In Karas Region, The Regional Council seems to be unaware of the problems thus essential maintenance is not taken into serious consideration.

In general, Municipality of Keetmanshoop does not have comprehensive and long-term development plans for water networks. Lately, the interest of renovating existing borehole line to the Municipality properties and installing remote water meters at the inlet of each suburb, have been on the table but no concrete actions have been made so far. Moreover, for decreasing serious water losses, the actions have been minimal. Municipality has ignored the source of the problem rather than trying to fix it. It seems that only methods for getting water supplying profitable have been tariff raising and finding ways to use own water sources.

However, in new development areas, in accordance with Municipality's Quiver Tree Newsletter (2008), Keetmanshoop is vigorously working towards attaining the goals set out in the strategic plan adopted by Town Council and dubbed Vision 2010. One of these goals is to build and service one hundred houses each year until 2010, under the Decentralized Build Together Programme (DBTP), which is administered by the Town Council. This program has started already in 1998 but in reality, this program has not been very successful and only 270 houses have been built until August 2008.

5.4. Water losses

In Keetmanshoop, for last few years, water losses have been significantly high. According to the research made during this project, unaccounted-for water has been between 500 000–700 000 m^3 for last five years, caused primarily by constantly leaking pipe network and other unmeasured water. To understand the situation better, Municipality's total consumption has been divided into categories in Figure 5.2.



	7/2004	7/2005	7/2006	7/2007	7/2008
Other unmeasured water	588 975	428 728	506 928	459 986	476 350
Municipality properties	75 852	75 852	75 852	75 852	75 852
Billed volume	1 086 643	1 091 537	1 056 439	1 051 624	1 030 119

***Figure 5.2.** Municipality's total consumption divided into categories*

All cabs represent the situation on first of July because water recording has been divided to periods of one year, starting from 1st of July and ending on 30th of June of the following year. Used categories need some clarification, "Billed volume" means the total consumption what have been sold to the domestic and non-domestic premises, "Municipality properties" means water used in Municipal cared parks, graveyards, stadiums and so forth. (See Appendix 7 for list with average consumptions) and "Other unmeasured water" means all the rest legitimate and non-legitimate water together. Almost all of it is caused by poor infrastructure and that is justified in the following chapters.

5.4.1. Legitimate use

Not long ago, Municipality properties' water consumption has been recorded once in a year, usually in April at least for 10–15 years. However, in 2008 recording has been stopped and during the survey to the Municipality properties, it was found out that almost half theirs water meters were inactive or stolen. Although this consumption has been recorded in previous years, it has not been indicated in the bookkeeping. It should be considered as an expense to the Municipality but it has not been even included in the budgets for last two years. Due these facts, Municipality properties' consumption can be considered as a water loss and legitimate unmeasured water. In the Figure 5.2., using old meter books, this unmeasured volume has been estimated for each year although it was difficult to extract the information hence the books were very unclear and illegible. In general, this practice has not been managed very well, the staff does not seem to know anything about the matter, these water meters are not taken cared by anyone and nobody is appointed to read them routinely.

Other legitimate use cannot be considered as a big issue. Municipality does not have any public standpipes or prepaid water meters in use anymore. Fire hydrants are not installed with water meters but firefighting and street irrigation are mainly done by Municipality tankers, which are filled from the Town borehole. According to the research, at least small diameter water meters should be recording properly and hardly ever, there are mistakes in billing. While cleaning a small diameter water meter, the recording unit is taken away and washed below opened tap in the compound; at least few liters are consumed. On yearly basis and according to the average amount of meter cleaning done per day, a yearly consumption is only 2–5 m^3. However, what comes to general infrastructure development and fixing, consumed water is impossible to determine.

5.4.2. Non-legitimate use

The biggest losses in Keetmanshoop are created by non-legitimate use and poor management. As stated in Chapter 4.3.8., also the majority of the problems in Keetmanshoop are caused by the old AC pipelines in the old town and rural areas. Pipes burst easily after sudden pressure changes and due to fragile pipe infrastructure, bursts are experienced all the time and everywhere. Moreover, problems magnifies when a critical shut valve does not work or cannot be found thus more water will be wasted while trying to find a way to shut down the cracked pipeline. In general, shut valves are in rather bad shape because of low maintenance, some of the valves do not operate at all and sometimes plumbers do not even dare to touch the shut valve being afraid of breaking it (due to oldness and sensitivity for movements). In addition, old valves and fire hydrants tend to leak and now and then small ponds can be found around them (see Photo 5.5. and photos in Appendix 9). During the two months research period, at least 10–15 leaking shut valves and fire hydrants were spotted as well as numerous sewer and water pipe bursts.

Photo 5.5. *Leaking shut valve and sewerage. © Risto Seppänen 2008*

Measuring the amount illegal use is difficult. Usually illegal actions are made towards the water meters and rarely any kind of bypasses are found out due to residents' slight possibilities to buy/obtain needed equipments and tools. However, cunningly constructed underground bypasses are the most effective ways to steal water thus suspecting the worst is right-minded.

5.4.3. Wastage outside of the Municipality's responsibility

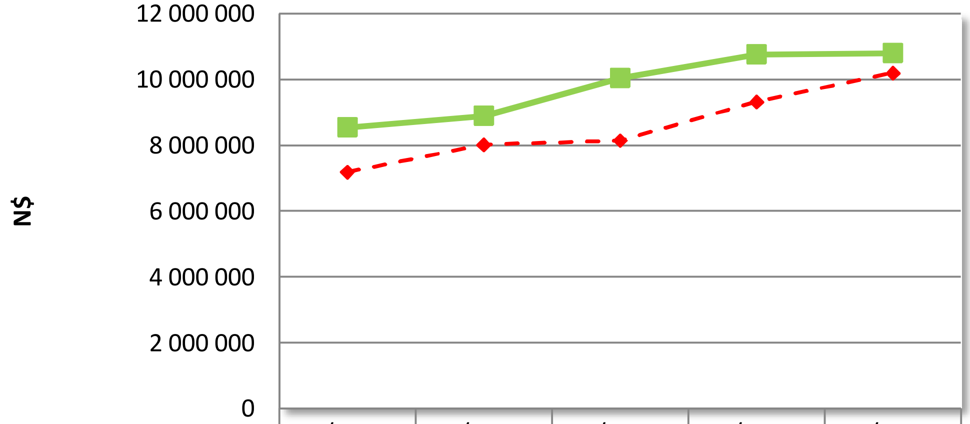
Even though water is going through water meters (which make water billed) in public premises such as schools and hostels, it would be interesting to know how much water is wasted due to leaking toilets and taps. In extreme cases, a big consumer cannot pay its significantly high bill to the Municipality causing incapability to pay water supplier's bill (NamWater). Unfortunately, this vicious circle continues until the problems are fixed. A good indicator of the volume water losses in public premises is the minimum flow level during the nighttime. Because hardly any legitimate use of water occurs during the night in these premises, it is obvious that almost all of this flow is wasted. (Pietilä 2005, 57)

During this research, a survey was made to eleven schools and hostels to clarify the situation. Firstly, meter readings were taken from the premises in the evening around 19.00–21.00 and then again in the next morning around 7.00–9.00. After that, differences were calculated and it was found out that almost 78 m^3 were wasted during the night. However, the result does not seem to be accurate because some of the premises had nightly activities although the survey was scheduled for the school holiday and one of the hostels had a very badly leaking gardening pipe. If mentioned errors are taken roughly into consideration, nightly consumption decreases around 9 m^3, which means about 20% (3 285 m^3) of the total yearly consumption of these premises. If the same pattern recurs in other public premises, it will mean a significant water loss in a large scale and if the water meters are not recording properly (which is probable), moreover the Municipality will be a loser.

5.5. Review on economy

According to the annual Audit Report on the accounts of the Municipality of Keetmanshoop (2006, 2), the percentage of distribution losses for water was unacceptably high and the Council was urged to take immediate steps to rectify this matter. In 2006, Keetmanshoop's official unaccounted-for water was 32,9 % and moreover, at the same time Municipality was experiencing serious financial problems as a result of the large outstanding debts. In the end of financial year 2006, the amount of outstanding was N$ 10 571 252. When this report was compiled, Municipality owned merely N$ 2 500 000 to NamWater due to unpaid bills. However, according to NamWater's Andries Kok, manager of Karas Region, NamWater is powerless to obtain its claims due to political reasons although the water supply has been cut once in Keetmanshoop (The Namibian 4.4.2005). The problem is nationwide thus NamWater has also cut water supply in other municipalities.

According to the Audit Report on the accounts of the Municipality of Keetmanshoop (2006, 5), water sales have been unprofitable with N$ 102 784 and in 2005 with N$ 226 629 negative surplus. Given bought volumes from NamWater are the same in both studies but the sold cubes to the residents differ. In Audit Report, Municipality has billed more than meter reading books have imply and the difference have been around 200 000 m^3 in both years. As a result of that, there is a conflict between the Audit Report and this research, which states that Municipality's water sales should have been significantly unprofitable for last five years. According to the research, if tariff changes and value added taxes have been taken into consideration, Municipality has lost approximately 6,2 million Namibian dollars (on average 1,2 million per year) during the years of 2003–2008 (see Figure 5.3). In accordance with NamWater's yearly increasing water tariff, the situation will not get better in the future without effective actions (see tariffs in Figure 5.4.).



	7/2004	7/2005	7/2006	7/2007	7/2008
Municipality N$	7 182 158	8 007 431	8 139 862	9 312 131	10 187 877
NamWater N$	8 540 168	8 882 687	10 028 742	10 758 757	10 790 638

Figure 5.3. *Municipality billing vs. NamWater billing based on meter reading books and NamWater's sold cubes. Changing tariffs are taken into consideration.*

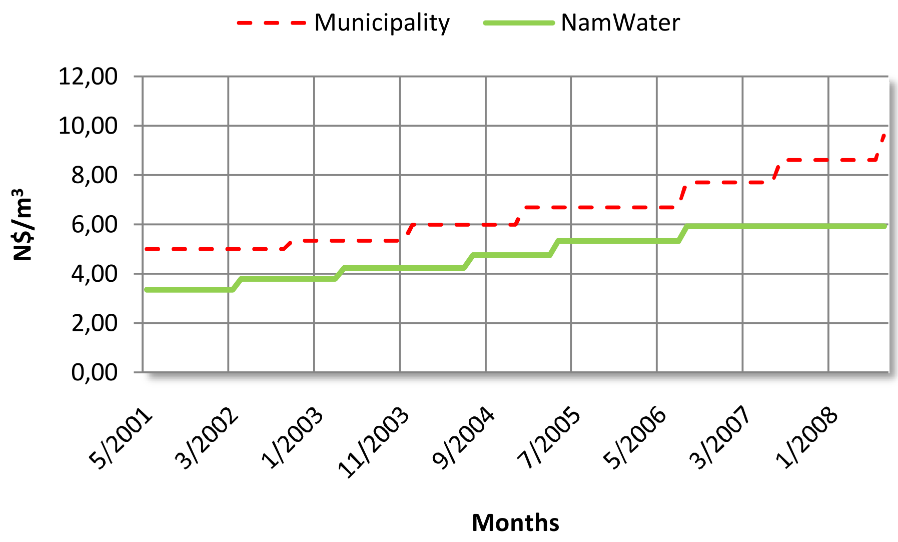


Figure 5.4. *Water tariffs*

According to the budgets (see Appendix 8 for budget for financial year 2008/2009) of technical services on water vote between years 2005 and 2009, it seems that network repair and maintenance have been budgeted around N$ 250 000–300 000 each year. For both 2008/2009 and 2007/2008 financial years, Municipality has also allocated N$ 200 000 per year for development projects but none of these lump sums have been used so far. Budget actualization has been quite accurate but what comes to staff expenses, overtime costs have been at least doubled each year from the budget. Natural explanation for this is the high amount of maintenance work. Other estimations seem to be under control but overall actualization does not promise profitable years in the future.

6. COMPARISON TO FINNISH MUNICIPALITIES

Finland is a country of thousands of lakes and islands, 10% of the total area is covered by water and 69% by forest. With area of 338 145 km^2, Finland is almost one third of the size of Namibia, populating 5,3 million people. The climate of Finland is marked by cold winters (-30 °C) and fairly warm summers (+20 °C) depending on the place where measured. Annual precipitation rate is on average 550 mm per year, less in the utmost north and more in the south. Rainfall is somewhat equal in every part of the country whereas in Namibia it varies a lot, southern and eastern parts are always dry but northern parts are often affected by floods. (Virtual Finland 2008; FMI 2008). See basic information of both studied countries in Table 6.1.

Table 6.1. *Basic information about Namibia and Finland*

	Namibia	Finland
Area (km^2)	835 418	338 145
Water (% of area)	Negligible	10,0
Population (estimation 2008)	1 820 916	5 319 953
Density (inhabitants/km^2)	2,5	16
Precipitation rate (mm/a)	0–700	500–650
Total water consumption (m^3/a)	300 000 000[2]	410 000 000[1]

Notes: 1) Estimation 2001
2) Estimation 2000

Sources: Statistics Finland 2008
FMI – Weather and Climate 2008
Finnish Environmental Administration 2008
Encyclopedia of Earth 2008

In the beginning of 2008, Finland had 415 towns classified as municipalities and 113 as cities. The designation does not have any legislative meaning and from the 1995, local authority has had the power to choose which classification they want to use. Finnish local authorities enjoy a strong, self-governing status and have the right to levy taxes. (Local Finland 2008; Wikipedia 2008: “Kunta”)

Local authorities finance their annual expenditure with taxes, central government transfers, various charges and sales revenues. Local income tax paid by residents, real estate tax and a share of corporate tax account for almost half of all municipal revenues. Each local authority decides independently on its income tax rate. The average local tax rate is 18,6% of taxable income. Fees and charges account for about a quarter of municipal revenues. Most of the customer charges are collected for services such as water supply, waste disposal, power supply and public transport. Just under one tenth of social welfare and health expenditure is covered through customer and patient charges. Basic education is free. (Local Finland 2008)

6.1. Water services in Finland

In accordance with the Water Services Act (2001), water and wastewater services are clearly the responsibility of municipalities in Finland. Due to extensive infrastructure, almost 90% of the population has access to municipal water supply (Local Finland 2008). At the ministry level, water sector responsibilities fall mainly under the Ministry of Agriculture and Forestry and the Ministry of the Environment. The Ministry of Agriculture and Forestry steers the Regional Environment Centres and Finnish Environment Institute in the use and management of water sources. As regards general administration, these are subject to the Ministry of the Environment, which also steers them in water protection tasks such as pollution control. (Ministry of Agriculture and Forestry 2008a). In addition, the Ministry of Social Affairs and Health gives recommendations for drinking water quality, and the Office of Free Competition within the Ministry of Trade and Industry oversees economical aspects in the water sector. (Vehmaskoski 2002, 70)

In practice, according to Pietilä (2006, 81) Finnish water and sewerage undertakings can be classified into three main categories based on organizational and functional model:

1. Small private water associations serving rural communities and sparsely populated areas within municipalities (partnerships, water cooperatives),
2. Municipal undertakings serving urban and rural centers (utility companies, joint stock companies),
3. Regional undertakings (federations of municipalities, joint stock companies)

6.1.1. Executive bodies

Finland has a long and extensive experience from public-private cooperation in the water supply and sewerage sector. Outsourcing of the services, especially non-core operations, of public water undertakings is very extensive in Finland. The contract period is purposely relative short, such as three years, in order to maintain real competition. Too long contract periods can eliminate potential competitors and thus reduce competition in the next round. Finnish public procurement legislation, which is based on an EU directive, requires municipal public utilities to arrange competitive bidding on investment projects larger than 5,3 million Euros (72,2 million N$), and on annual services or goods purchases exceeding 0,2 million Euros (2,7 million N$) (Ministry of Employment and Economy 2007). Private companies incur nearly 100 percent of the capital expenditures of Finnish water systems. (Pietilä 2006, 78). In real terms, municipalities' utilities arrange competitive biddings even on investments under 10 000 Euros (N$ 130 000).

According to Vehmaskoski (2002, 91–95), the most commonly outsourced services are:

- Detailed design
- Construction
- Wastewater sludge treatment
- Equipment and material supply
- Repair workshop services
- Laboratory services
- Other none-core services (such as transportation, machinery leasing, automation, instrumentation and control, computer services, office and real estate services)

Although Finnish municipalities are in principle responsible for water and wastewater services, it does not mean literally that municipalities have to bring pipelines to every household. Municipalities have the overall provision and development responsibility within their areas. Finland is a large country with vast sparsely populated rural areas where the basic responsibility for water and wastewater services lies with the property owner. This means that rural property owners cannot demand the municipality to arrange water and wastewater services for their property, but have to find their own solution. (Pietilä 2006, 20–21)

In the rural areas of Finland, water cooperatives are common means of organizing water supply. Water cooperatives have a long history in Finland – the first were established already one hundred years ago and in 2004, there were 950 of them (Finland's Environmental Administration 2008). Rural municipalities established piped water supply systems to cover the built-up centers of the municipalities, but they could not afford extending water distribution to sparsely populated, predominantly farming areas, outside the centers. Thus, people joined their forces to draw water from distant sources since it made sense to work together for a common goal. Cooperatives has been established for other common undertaking and became commonplace also in water supply. (Pietilä 2006, 81)

6.1.2. Finance

Legislation has stipulated since 2001 that all costs, including investments and replacements, related to water and wastewater services have to be covered by the fees collected from the service users. However, water services can be subsidized by the municipality, the state, and the European Union in accordance with the Water Services Act (2001, 18§). The government support has been directed mostly to investments in smaller municipalities and important regional systems. Larger cities have never received any financial support for their water services from the state, except for some regional water supply schemes. No governmental subsidies are available for operations and maintenance, that is for operating expenditures. In addition, in order to improve transparency municipal water utilities have to keep separate bookkeeping from the municipality. (Pietilä 2006, 20, 77)

6.1.3. Water sources

Unlike in Namibia, Finland does not have any national bulk water supplier because water can be obtained extensively from every part of the country. The majority of water for household consumption is produced from groundwater and almost 6 350 aquifers have been mapped and classified in Finland. More than half of these reserves are exploitable for the water supply and it is estimated that Finland's aquifers are replenished by an average of almost 5,4 million cubic meters of water a day. Finland currently extracts around 0,7 million cubic meters of groundwater a day. Since the 1970s, the use of groundwater has steadily increased in municipal water supply and it accounts for around 60% of the water distributed by waterworks around the country. The rest water for household consumption is produced from surface water. (Finland's Environmental Administration 2008; VVY 2008)

In sparsely populated areas, the population living outside piped water supply systems use groundwater from dug wells or boreholes in the Precambrian rock. A special feature of Finland is that there are numerous holiday residences (summer cottages) in rural areas, typically by lakes, which used to be inhabited only during summer holidays, but are nowadays increasingly used the year around. These building are outside population centers and thus have to rely on their own water supply systems. Private water supply systems include some 450 000 dug wells and 150 000 boreholes. (Finland's Environmental Administration 2008)

The capacity of natural groundwater formations can be increased by recharging surface water into the ground. The quality of water improves as it filters through the soil. This artificially recharged groundwater makes up 12% of the public water supply in Finland, and 25 waterworks currently use this method. (Finland's Environmental Administration 2008)

6.2. Kangasala and Lempäälä

Kangasala and Lempäälä are medium-sized Finnish municipalities situated in the very developed industrialized Tampere Region in the southern part of Finland, approximately 160 north from the Finnish Capital town Helsinki. The population in the area is fast growing and the economy is based for instance on high-tech, automation and modern services industry. Lempäälä with similar size class to Kangasala are neighboring municipalities around the City of Tampere. (PLDDSI 2008). See basic information from Table 6.2.

Table 6.2. *Basic information of Finnish municipalities compared to Keetmanshoop*

	Keetmanshoop	Kangasala	Lempäälä
Basic information 2008			
Area (km^2)	–	651,3	306,9
Water (% of area)	0	24	12,2
Population	16 800	27 733	19 271
Density (inhabitants/km^2)	–	54,6	71,8
Water statistics 2007			
Length of water network (km)	150	277	211
Amount of water meters	3 514	4 500	3 800
Pumped water into network (m^3/a)	1 582 321[1]	1 934 334	1 493 676
Unaccounted-for water (%)	37,5[1]	14,1	17–18
Daily per capita consumption (l/person/day)	188[1]	180	174

Notes: 1) Recording period July 2007–June 2008

Sources: Wikipedia 2008: “Kangasala” & “Lempäälä”
Statistics of Kangasala Water
Statistics of Lempäälä waterworks

In both municipalities, waterworks are strictly considered as units under technical departments whereas in Namibia, water services are generally “hidden” inside the technical departments. Kangasala Water is a public utility administered through Municipality of Kangasala, but Lempäälä waterworks is part and parcel of the Municipality’s organization. Practically, the difference is subtle; Kangasala Water can decide its water fees independently and has its own CEO while Lempäälä has to submit fees through municipal council and director’s title is water management engineer. However, both utilities have the same duties and own bookkeeping. Chart 6.1. introduce Kangasala Water and Lempäälä waterworks’ organizational charts and relations to the municipal organizations.

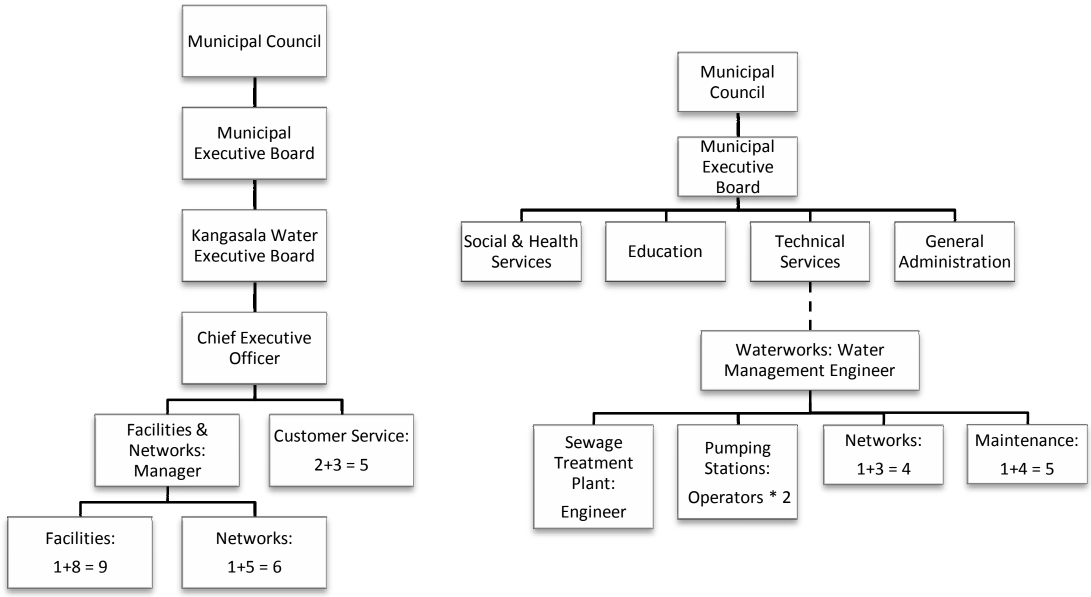


Chart 6.1. *Organizational charts of Kangasala Water (left) and Lempäälä waterworks (right)*

In November 2008, Kangasala Water had altogether 21 employees and Lempäälä waterworks 11. Not all of the workers are included inside organizational charts because special skilled workers, such as electricians, are usually lent from the Municipalities' technical services.

6.2.1. Water sources and quality

Kangasala's main water intake (Riku) is situated at the shore of Vesijärvi about 4 km northwest from the center of the town. Raw water is pumped through four wells from the aquifer where the lake's water has been soaked. Daily amount of pumped and treated water is about 3 600 m^3. Another source of water is the ridge of Vehoniemi, where water is pumped (2 000 m^3/day) from the aquifer to the water treatment plant of Raikku. In both cases, water is disinfected and pH adjusted before left to the distribution network. For emergency cases, Kangasala has also two connections to Tampere's distribution network to yield 300–600 m^3 of treated water per day when necessary.

Municipality of Lempäälä has three own water intake plants: Leukamaa, Sotavalta and Lempoinen. Daily yield is altogether about 1 200 m^3. In addition, waterworks purchases treated water from Tampere Water and City of Valkeakoski on average 2 000 m^3 per day. In the end, acquired water depends of fluctuation of groundwater level and water sales. Waterworks provides treated water also for neighboring municipalities such as Vesilahti, Pirkkala and Viiala. Raw water is treated at the plants, before let to the distribution network.

Water quality is monitored, in accordance with the Decree of the Ministry of Social Affairs and Health Relating to the Quality and Monitoring of Water Intended for Human Consumption (2000), by municipalities' health inspectors. Health inspectors take samples from random parts of the distribution networks and deliver them to laboratories for analyzing. Monitoring and quality requirements are directed for water coming out of consumers' taps.

6.2.2. Infrastructure and maintenance

Kangasala's water distribution network is 277 km long and Lempäälä's 211 km. Although both municipalities have a long history, first indications of population are from many hundreds years ago, industrialization and constructing of water infrastructure have started as late as 1950s (Äikäs, Juuti & Katko 2003; Lempäälän kunta 2008). Because of that, oldest parts of the water networks are at least 40 years old. Main pipe materials for water and sewerage have been cast-iron, asbestos cement, concrete, variations of PVC and polyethylene (PE). Plastic materials were introduced in first place at 1960s and since 1970s; they have been the main pipe materials. In 2005, 89% of all water network pipelines were plastic in Finland (Ministry of Agriculture and Forestry 2008b, 6). Lately Lempäälä has been using new polypropylene pipes (PP), which are more environmental friendly due to advantage of non-polluting disposal while for example PVC cannot be burned. Normally pipelines are laid less than two meters due to frost in the ground at winter times. However, zone of frost penetration varies a lot thus any general installation depth cannot be given for the whole country. Usually, pressure classes are 10 kilopascals but some 6 kilopascal pipes are used as service pipes.

In Kangasala, main water storage facilities are water towers in Harjunsalo, Kirkonkylä and Lentola, whose shared capacity is 2 100 m^3. In addition, newly built Sahalahti water tower can bear 2 000 m^3. Water is boosted in the network by seven booster pump stations and whole municipality has been divided into eight pressure zones. Water flowing and pumps are monitored in an observation room, where current situation can be checked at critical points of the network. Ad-hoc maintenance is organized by Municipality's own on-call duty center, where a duty officer acts on emerged situations when necessary.

Lempäälä has been divided into four pressure zones, pressurized by four booster pump stations as well as Sääksjärvi (700 m^3) and Hakkari (1 000 m^3) water towers. There are also few smaller tail-water storages in the town. Town has not been divided in very clear monitoring zones hence accurate information about current flow or pressure rates cannot be obtained remotely. However, all pump stations and some critical points are in the computer system, so that the most critical information will be delivered to the duty officers. Lempäälä has similar emergency system than Kangasala and currently there is a group of four duty officers, which takes care of the monitoring. One officer is responsible for one week at a time, so that he has to be at the office at weekdays from 7.00 to 15.30. After hours and weekends, current officer has an emergency mobile phone and a laptop computer to establish remote connection to the monitoring devices at the office if necessary. These emergency systems are used for every municipal ad-hoc situations from water issues to road maintenance.

General and ad-hoc maintenance towards water network is mainly done by waterworks' own plumbers and municipalities' general workers. In special occasions, specialists are subscribed from private companies as likely as pipes and parts from wholesalers and vehicles from private suppliers. Municipalities do not have their own excavators or trucks, and stores can provide only the most used pipe types and parts. Fortunately, municipalities (and waterworks) have reliable "day and night" contacts for private contractors in order to get machines or vehicles in emergencies. On average, both municipalities have one pipe burst in a month.

Shut valves are not checked frequently either in Lempäälä or in Kangasala and that is a clear deficiency. Fortunately, currently they are working and only few are reported to be non-functional. Shut valves can be clearly spotted on the ground although the valve itself is as deep as the pipelines. Typically, cast-iron hatch on top of the ground is connected to the valve by a plastic pipe to keep the path open. These valves are operated by a special long stick from the surface. In Lempäälä, fire hydrants are checked and maintained on yearly basis by private companies but Kangasala does not have routine checking system at all.

In both municipalities, maintenance of water meters is privatized. These companies are responsible for accurate operation of the meters and general maintenance. Installations are mainly done by the waterworks' plumbers and overall goal is to use each water meter for ten years and then replace it with new one.

All valves and fire hydrants are included in the CAD layouts in both Municipalities. Kangasala has even employed a specialist for measuring the exact locations of different parts of the system. In general, all layouts of each Municipality's are up-to-date. Both Municipalities have full-time planning assistants who take care of all town layouts. However, in case of new developments, extra help is often ordered from private engineering companies.

6.2.3. Water connections and metering

Consumer, who is connecting to the distribution network, is responsible for providing service pipe to the main. Waterworks' plumbers make the connection and install water meter inside the house. All these operations have fixed fees. In case of pipe burst, consumer is responsible for repairing the fault from his house until the main. Meter sizes are typically 15–20 mm in single-family houses but in multi-storey and office buildings, factories and so forth, normal size is from 20 mm up to 100 mm. Meters are typically simple mechanical working types, which do not give possibility for remote reading, although some municipalities are starting to use them for domestic purposes also.

Even though water undertakings seldom have problems with the availability of water, all sold water is recorded when delivered to the customers. Usually multi-storey residential buildings have only one meter; dwelling-based metering is rare. Single-family houses, on the other hand, always have their own meter. In Finland, the reading of water meters by water utilities staff is getting rarer. Many utilities send a stamped postcard to customers once a year, and ask them to fill in the water meter reading and mail it back to the company. (Pietilä 2006, 77, 79–80). Alternatively, for example in Lempäälä and Kangasala, customers can phone in the reading or send the reading via internet. The meter reading is then checked in connection with the meter replacement and occasionally in between. In single-family houses, water usage is billed in three-month periods whereas in multi-storey buildings water bill is usually included in monthly condominium payment or rent. Because multi-storey buildings have normally only one water meter, bill is allocated to each apartment on average basis in accordance with the amount of consumers and apartment's size.

6.2.4. Development

Concerning the present state and future of the pipeline infrastructure in Finland, Ministry of Agriculture and Forestry has ordered a research to analyze the situation. First version of the research was compiled in 1992 and updated version was carried out in 2008. This YVES 2008 –research points out known problems in the infrastructure and management as well as estimates the need of renovation. According to the research, in Finland 2008, 6% of all water pipelines were in bad or very bad condition likewise 12% of all sewerage pipes. However, situation has clearly improved from time when the first research was made thus renovations are realized slowly but surely. On average, both water supply and sewerage pipelines are renovated 700–900 km per year. (Ministry of Agriculture and Forestry 2008b, 19–20). According to the literature survey, Finnish water distribution and sewerage systems are rather well monitored and studies are made broadly. Consequently, conscious of the problems is broad.

Kangasala Water's development plans have been bundled up as an extensive Municipal Water Supply and Sewerage Development Plan 2004–2030. As well as YVES 2008 research, Kangasala Water's own development plan is an analysis of the current situation, supplemented by future improvements. Current pipeline infrastructure is adequate for supplying water in normal situations; however, securing steps will be realized for state of emergencies and availability of good quality water especially for rural areas. Municipality has also huge investments for next few years to provide services for new development areas as well as to renovate old network. In order to reduce UFW rate progressively, Kangasala Water keeps up routine replacement plan for old pipelines. In past two years, water supply network has been renovated on average by 0,3 km per year. New water supply pipelines have been built approximately 2,6 km per year (2006–2007).

Lempäälä waterworks do not have any long-term development plan. However, according to the water management engineer, main objectives are to reduce UFW rate and to ensure sufficient network capacity for growing water consumption in the future. Municipality is growing fast in next few years thus providing services for new development areas is one of the spearhead targets as well as extending remote monitoring system in smaller sections. On average, new water supply and sewerage pipelines are built both 4 km per year and storm water pipeline 2 km per year.

6.2.5. Financial aspects

For covering expenses of service provision, waterworks collect connection fees and fixed charges according to consumption from the consumers. All charges are based on legislation (Water Service Act, 2001) but waterworks may have their own service tariffs.

Magnitude of water connection fees for new developments depends on few variables. In both municipalities gross floor area according to building permit is the main factor but type of the house and its location can affect to the total fee also. On average, connection fee can be for a single-family house from 13 000 up to 19 500 Namibian dollars (1 000–1 500 €). In addition, consumers must pay yearly-based basic fees in accordance with the size of the water meter or total consumption. Similar charges are allocated for storm water and sewerage connections. User fees for potable water and basic charges can be obtained from Table 6.3.

Table 6.3. *Water tariffs in Keetmanshoop, Kangasala and Lempäälä in 2008 (excluding VAT's)*

	Keetmanshoop		**Kangasala**		**Lempäälä**	
Water tariff ($\text{N\$/m}^3$)	8,60 (0,66)		12,74 (0,98)		15,34 (1,18)	
Borehole tariff ($\text{N\$/m}^3$)	4,40 (0,34)					
New connection ($\text{N\$/m}^3$)[1]	160,00 (12,31)		13 000–19 000 (1 000–1 500)		13 000–19 000 (1 000–1 500)	
Basic charge (N$/year)	Type		Consumption		Meter size	
	Residential	36,30 (2,79)	< 50 m^3/year	234,00 (18,00)	15–20 mm	514,80 (39,60)
	Senior	No charge	50–300 m^3/year	421,20 (32,40)	21–40	1950,00 (150,00)
	Non-residential	155,85 (11,99)	300–1000 m^3/year	826,80 (63,60)	> 40 mm	5460,00 (420,00)
			1000–2000 m^3/year	1606,80 (123,60)		
			2000–5000 m^3/year	3135,60 (241,20)		
			> 5000 m^3/year	6115,20 (470,40)		

Notes: 1) For single-family house
Values in brackets are in Euros

Sources: Kangasala Water
Lempäälä waterworks
Municipality of Keetmanshoop

Bottom lines of profit and loss accounts are in very different scale in Finnish municipalities' than in Keetmanshoop. Table 6.4. combines few key figures.

Table 6.4. *Key figures of waterworks' economy*

	Keetmanshoop Budget 2008/09[1]	**Kangasala Actual 2007**	**Lempäälä Budget 2008**
Volume of business (N$)	23 594 169 (1 814 936)	59 072 000 (4 544 000)	53 318 460 (4 101 420)
Business surplus (N$)	369 831 (28 449)	6 877 000 (529 000)	16 418 740 (1 262 980)

Notes: 1) Only for water vote (excludes sewerage)
Values in brackets are in Euros

According to investment plans of both Finnish municipalities, it seems that they are spending 50–60% of their turnovers to investments and development of the water system. In Keetmanshoop, the same percentage is only 2. However, the considerable difference can be explained, at least partly, by following facts: 1. Water infrastructure in Finnish Municipalities is vast, it consist of tens of pumping stations, reclamation plants, water intake plants, water towers, both water supply and sewerage pipelines, and storm water pipelines. Investments are allocated for all sections of water infrastructure. 2. Kangasala and Lempäälä are largely growing municipalities, 3. tradition of development is rooted in policymakers, and 4. legislation stipulates strictly condition of water supply and waste management.

6.2.6. Known problems

Finland is one of the top-ranked countries in the world in water management. According to the newly developed international Water Poverty Index (WPI), Finland classified first with 77,9 points in 2002.WPI is a combined evaluation of five major components of water management. (Lawrence, Meigh & Sullivan 2002). Consequently, Finnish municipalities' do not suffer as tremendous UFW rate as Keetmanshoop. Water networks are well realized, availability of water is good and pressure rates are excellent at least in urban areas. Residents have both warm and cold water supply and taps are inside the houses. On average, water quality is fine and suitable for human consumption. Hardness is at soft level and lime does not act as a substantial issue. To top it all, waterworks' financial situations are advantageous.

Clearly, problems are less considerable in Finnish municipalities than in Keetmanshoop. However, reviewed features are not always advantages. When one has got used to good service, exceptional situations bothers. Lately, some Finnish waterworks have gone under serious castigation because of clear errors on purity of water. In the end of 2007, Nokia waterworks made a critical mistake when letting accidently 400 000 liters of wastewater to fresh water network. In addition, in 2008, somewhat similar incident happened in the City of Ylöjärvi. Both of the incidents were largely discussed in media and caused many troubles, including health problems and strong prejudice towards municipalities' water network management in the whole country. Moreover, both reviewed municipalities have a lack of routine maintenance for shut valves and Kangasala Water also for fire hydrants. Although, shut valves and fire hydrants seem to be operating now, it is inevitable that someday problems occur.

For environmental aspect and considering current shortage of water in the world, high water pressure rates are tailor-made trouble to nourish water-wasting habits. In 2001, average per capita consumption was approximately 242 liters per individual per day (Finnish Environmental Administration 2008). Current level of UFW in reviewed Finnish municipalities is not ideal either. Meanwhile, Windhoek represents good examples of leakage control and keeping water wastage at minimum. In Lempäälä, leaks formulate 10% of the total water consumption, the rest 7–8% are estimated to be management issues. Management issues formulate the most difficult part to handle because the reasons are sometimes hard to find and efficient recording methods are expensive. Both municipalities considered network flushes, freezing ice-hockey fields and usage of fire hydrants considerable consumers but either one do not have possibilities to record the usage. Illegal use was not considered as a substantial issue because hardly ever illegal connections or the like are found out.

7. DISCUSSION

The topic of this research is certainly important. In current climate and local conditions, wastage of water is absurd. Municipalities in Namibia are in a very unequal position when compared with each other. Less developed municipalities understand the need of proper water network management but do not have resources to sort out the nature of the problems. As consequence of that, inappropriate and inefficient actions are made to solve the matters. On the contrary, old colonial capitals and tourism centers are doing fine, UFW rate is on average at European level and water infrastructure development is funded.

When the Namibian municipalities are compared to the Finnish counterparts, it is clear that the magnitude of the problems is very different. Finnish waterworks are funded adequately and do not have that magnitude problems with water infrastructure or water resources. However, there is always something to be complained, residents of Finland are very aware of the quality of the water and even tiniest errors in the purity will be notified. On the contrary, Namibians do not consider quality of water as the primal objective but providing water for residents in general. Namibia is one of the driest countries in the world, water resources are the leading issues and after that comes “irrelevant” matters such as water delivery and purification.

Chosen research methods were found out to be suitable for this kind of study hence research questions assigned in the beginning were answered fairly during the project. However, more detailed outcome would have become more useful for the Keetmanshoop Municipality because, for example, sorting recommendations according to cost-efficiency would have provided a practical starting point for the Municipality. Currently, recommendations provide only ideas for improving the situation. On the other hand, presenting such a thorough approach would have needed more deep investigation on economical matters such as finding out prices in general. It would have been time consuming and time was short.

Analysis on Finnish water network management seemed to shape up only as a general overview of the practice in Finland. Again, it would have been beneficial to study their practices in detail at the base level to find out more practical and easily adaptive methods for improving the target of this research, Keetmanshoop water services. Now, Finnish angle provides only general information, which is interesting as itself, but there are many researches made of this subject already.

7.1. Self-evaluation

The scope of this research was realistic but more time would have been needed in order to get more accurate picture about the situation in Keetmanshoop and to collect representative source material. Therefore, some information does not represent the overall situation. However, this study is not doomed to be incomplete but it should be continued by the staff of the Municipality of Keetmanshoop.

Cooperation with the Namibian student Andreas Angula and the staff of the Municipality were smooth and fruitful although culture and habits were certainly different from Finnish. However, after first two weeks of adaptation in Keetmanshoop, everything started to work out fine. Unlike author's prejudice, native languages did not become too big problem although Afrikaans and Nama were the predominant languages, especially among the old people. While interviewing them, interpreter was needed causing inaccurate answers and most of the outcome of the interviews had to be checked again from other sources. Although English is the official language of the country, it is not sure that everyone speaks it fluently. In some situations, more patience would have been needed to figure out the situation unambiguously. Like in physical tests, incremental sensitivity causes margin of error. The same happens in interviews, where interviewee does not understand what interviewer asks or other way round. This error may have caused solitary mistakes to the source data.

Like stated before, equipment tests were made too few to generalize the results. Kent meters were tested somewhat adequately but more of the other types should have been tested. Moreover, tests should have been made with bigger container in order to get results that are more accurate. On the other hand, releasing water on the ground is not justified in informal areas, where shortage of water and money is considerable.

7.2. Need for further research

According to the deficiencies mentioned in the previous chapters, several topics would need further research. In order to intensify knowledge of water wastage outside of Municipality's responsibility and losses though non-recording water meters, it is useful to spend some time on checking functionality of water meters and condition of sanitary equipment in big premises. It is presumable that 25–100 mm water meters are not as accurate as smaller diameter meters. In addition, equipment tests for small diameter meters should be continued to find data that are more reliable.

To base future network development plans on more suitable basis, it is useful to know what kind of pipe materials have been used in every part of the network. Current, electronic version of the water network layout provides such information but its accuracy should be checked extensively.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1. Conclusions

Due of the target of the research, conclusions and recommendations are compiled for Municipality of Keetmanshoop although the same information is valid everywhere in Namibia and Finland with local revisions. According to research made during the period of two months, it was found out that all the problems accumulates to high amount of unaccounted-for water. Based on the volume of billed water, Keetmanshoop Municipality's water loss has been between 500 000 to 700 000 m^3/year at least for last five years, which means 33% to 35% loss per year. If all tariff changes and value added taxes are taken into consideration, the loss of income for selling water has been, for last five years, approximately N$ 6 200 000.

The reasons for high unaccounted-for water can be short-listed into three categories:

a) Fragile infrastructure
b) Unrecorded consumption and illegal use
c) Insufficient management and resources

8.1.1. Fragile infrastructure

Although Keetmanshoop water network is planned and realized quite well, taking into consideration pressure rates and availability of water, old and fragile infrastructure is tender for every kind of operations and causes troubles daily. Leaks of the network, in forms of leaking pipes, shut valves and fire hydrants, took about 29% of the total purchased water from NamWater in 2007–2008. Pipe bursts happen daily and maintenance costs are high due to cost of replacing parts and high amount overtime hours spent on replacing and repairing pipes. Currently, water distribution network is a mixture of different kinds of pipe materials because of the simple replacing routines presented in Chapter 5.3.4. However, this kind of pipeline replacing system is not cost-efficient in the end. For example, when one part of old AC pipeline is replaced, after a while new burst may occur just few meters further making previous replacing unworthy. Non-functional and inexistent shut valves extend the problem even bigger.

New areas' main pipelines have been built of uPVC but only from 2004, before that, asbestos cement has been the main pipe material. Nevertheless, asbestos cement cannot be blamed for all the difficulties because sometime new uPVC pipes can leak due to poor installation, weak joints or low pressure durability (low pressure class). AC pipes are sufficient when they are new, and pipes, which were installed in this century, should be adequate for at least 20 years. In the future, also uPVC will inherit the same downfall than AC pipes. UPVC cannot be burned without releasing toxic gases and proper after-treatment does not exist. Also Finnish municipalities will face this problem in the future.

8.1.2. Unrecorded consumption and illegal use

Under the category of unrecorded consumption and illegal use, can be included all consumer based illegal actions towards the water network and all water what is not recorded and billed. During the research, it was proved that smaller diameter water meters are recording quite accurately thus, water is not wasted through them. However, this estimation does not count in bigger diameter water meters and example about nighttime consumption described in Chapter 5.4.3. is closely argued. Due to insufficient management, significant water loss has been identified from Municipality's own backyard. Municipality cared parks, cemeteries, stadiums, offices and stores have not been metered and billed properly for last few years taking 5% of the total annual consumption. Illegal use and daily plumping routines are difficult to measure hence estimations cannot be given. Illegal connections, by-passing, tampering, reconnections after cut-offs or the like, are troubling Municipality's water staff by forcing them to concentrate on irrelevant matters.

Regardless, few typical water wastage sources can be set aside. Firefighting seems to be in order while using chiefly borehole water, public standpipes are not in use, every plot is equipped with water meters and billing systems is adequate and accurate. Water for street maintenance and cleaning is taken from boreholes and network flushing is rare (which is not necessarily a good thing).

8.1.3. Insufficient management and resources

As stated in Chapter 4.4.2., high amount of water losses accumulates to management issues. Management is in the position of giving initiatives and the first practical moves, and if these are not done, plans and actions are cancelled or delayed. Keetmanshoop have had problems with administration due to lack of key persons in all departments, which have caused delays and ignorance on water services thus not all maintenance has been done, developments have been put aside. In concrete, Keetmanshoop does not have any sustainable development plans for improving water network infrastructure and clear malpractice has been identified.

In addition, the use of boreholes have been found to be inefficient, water is being stolen and recent actions have been inadequate to put boreholes in productive use. Municipality is also struggling between weak financial situation and high demand of new infrastructure. Due to insufficient resources given by the Regional Council, Keetmanshoop is alone with its issues on water distribution network thus Municipality cannot provide enough money or resources for proper planning and renewing.

8.2. Recommendations

Primarily, all recommendations aim to decrease high rate of unaccounted-for water, however some additional suggestions have been included to give tools for better water network management in general. It is therefore suggested that the Town Council and Municipality's staff should consider recommendations in the following chapters.

8.3.1. Development of the infrastructure

a) Development plan for renewing old infrastructure

The majority of water losses have been caused by poor pipeline infrastructure thus a renovating plan must be carried out soon. However, it is not easy to rectify a large system of this sort in a short time; the approach has inevitably to be in progressive stages of improvement. First, installation of new shut valves in critical location allows future replacement more easily without having to shut down water supply from vast areas. Suitable locations can be found from the water network layout and with observation in the field. It could be wise to allocate money in each year to replace pipes and valves in some areas, not just for general maintenance. In addition, the Regional Council should be pressurized to get involved in the matter. In case that renewing plan will be compiled, it is recommendable to start from the main lines in surroundings of the town to avoid slowly reported pipe bursts and huge water losses in the future. In addition, Municipality should be aware of some useful techniques of replacing pipelines. It is not always cost-efficient to dig up the old pipeline; instead, new pipe can be installed inside the old one thus no extra efforts are needed to get rid of the old pipes.

b) New all-covering maintenance plan

All maintenance routines should be checked, allocated to proper instances and a new frequent system to check all shut valves must be started. Furthermore, all shut valves should be located in properly built man-holes (concrete), not just under weak bricklaying, and marked properly. In case of theft of the man-hole covers (or whatsoever), another offence than a big fine must be allocated to make stealing less attractive. In addition, reservoirs must be included in the maintenance plan to avoid unpleasant surprises of contamination. Municipality could also start a simple computer log, to store information about replaced pipes, water meters and others to get it more reachable.

c) Zone metering

In order to control water flows in each suburb or area of the town, it is strongly suggested to start a zone metering practice. With remotely controlled electronic water meters at the inlet of each suburb, the Municipality could watch water flowing rates from each area in real time. From water pressure graphs and pressure peaks in the network, maintenance team can see immediately if the water distribution is leaking and for statistical purposes, consumptions per area can be easily exported from the system. However, in order to start the practice, Keetmanshoop water distribution network must be divided into own pressure zones. Otherwise, metering will become too complicated. Pressure zones would also enhance pressure rates in the residences.

d) Mapping and silent information

To avoid losing shut valves and pipes; literally, mapping should be up-to-date all the time. Use of soft-copies is advisable due to easy updating process but if Municipality's staff is unable to do that, skill improvement possibilities should be introduced. Furthermore, it would be wise to have plotter services near to printout bigger layouts. Silent information should not be allowed to slip away from the Municipality. Knowledge of the old plumbers and general workers should be included in the maps and distributed to new workers before it is too late.

8.3.2. Tools for controlling unrecorded water

a) Metering routine for Municipality's properties

In the first place, all Municipality properties must be included into metering routines. Recording frequency should be the same than residential recordings in order to be aware of the condition of the water meters. According to observation, current meter readers should have time for that.

b) Consumer water meter testing

Consumer water meters should be tested in regular basis to get an idea how accurately they are recording. Knowledge should be shared between other municipalities to get the best equipment in use. Kent type meters and Sensus plastic meters have been found to be accurate in residential use thus replacing old meters with new ones could be noteworthy.

c) Decrease water losses where Municipality's responsibility ends

Although Municipality is billing every drop what is recorded by the consumer water meters, it is advisable to suggest public premises and residents to renovate their sanitary equipment and general plumbing to avoid water losses. Furthermore, in new development areas it is advisable to considerate other possibilities to replace fresh toilets with dry toilets or at least use modern toilet basins, which have two flushing options: smaller and bigger flush.

8.3.3. Management and ideas

a) Use of boreholes

Use of boreholes is an efficient way to decrease the cost of used water. Municipality should complete the plan to supply swimming pools, caravan park and stadiums from the Town borehole. In addition, possibility of using Town borehole for irrigating park islands on the roads should be considerate although it seems to be difficult due to high cost of building new pipelines. Borehole water cannot be inserted into existing water distribution network without purification. In Tseiblaagte, Ileni's borehole is supplying only Regional Council's owned fish farms and green garden but the water supplying capacity seems to be much bigger. Moreover, Tseiblaagte's second borehole is supporting water only to the Tseiblaagte Stadium. Local *Nama* community has suggested that a new tourism attraction site could be created in Tseiblaagte, consisting of accommodation services, souvenirs shops or something else similar. It could be funded partly by the Government but some of the resources such as water, could be obtained from the Municipality. In addition, borehole water selling strategies should be considerate, for example, how Ileni borehole's water usage could be billed.

b) Tariffs

Increasing block tariff is used widely in the country. It is a useable method to balance water-wasting habits and get more money from the largest consumers. Nevertheless, calculations should be made first, to prove it worthy. However, if current practice is to be remaining, it must be remembered that continuous water tariff increasing will not solve the problems on water losses.

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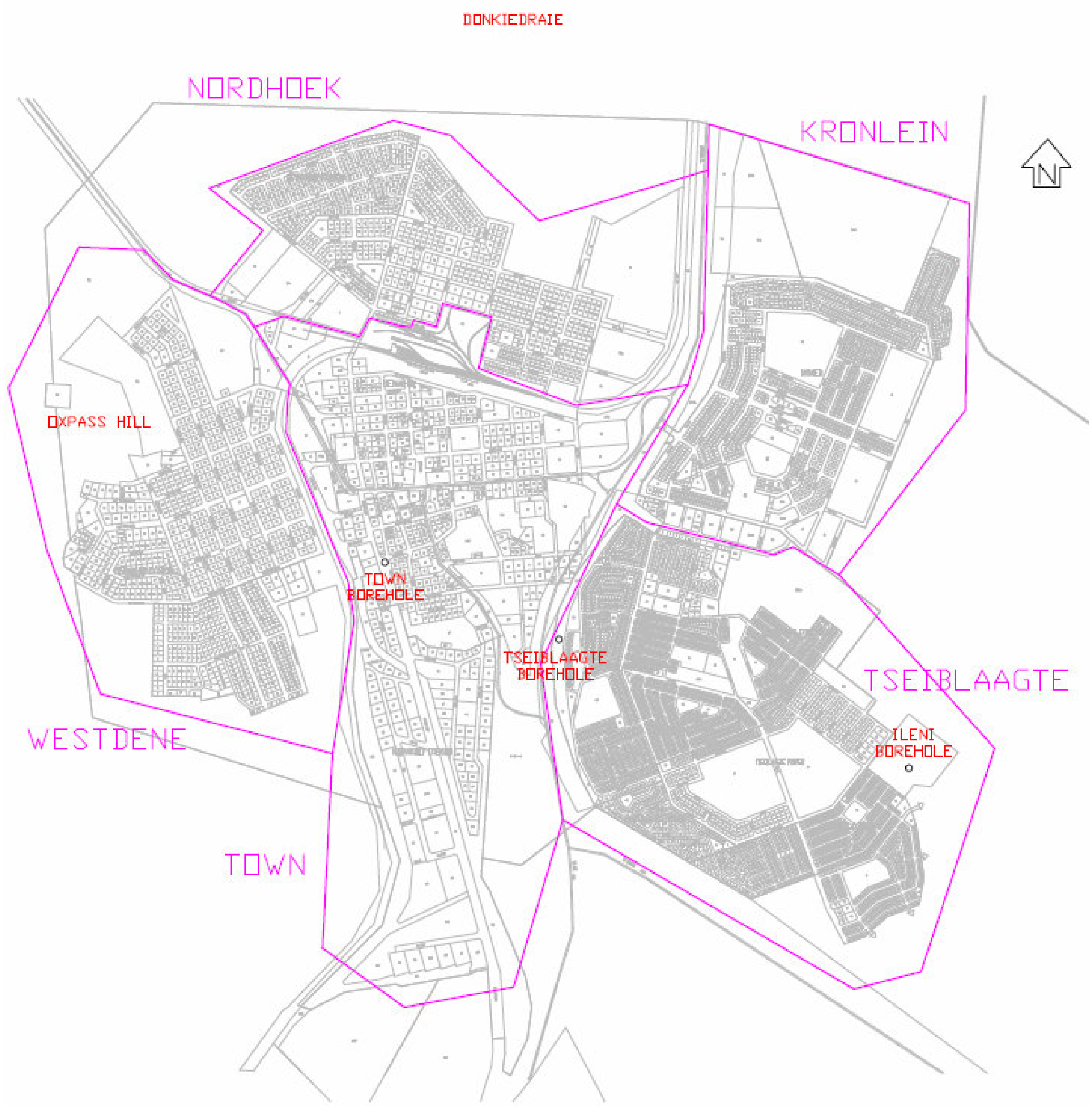
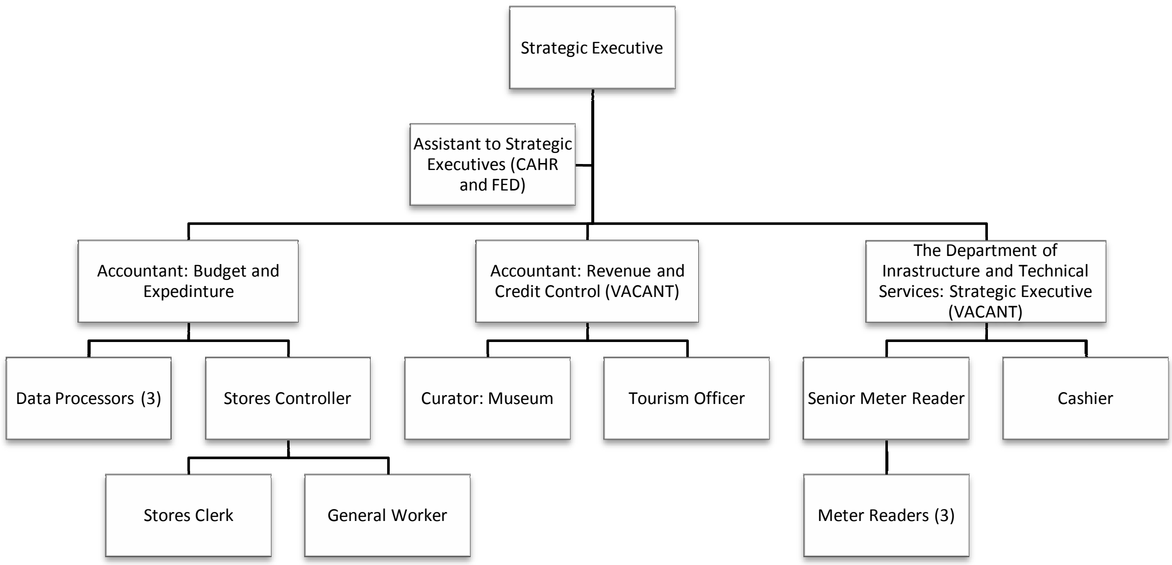
APPENDIX 1: MAP OF KEETMANSHOOP

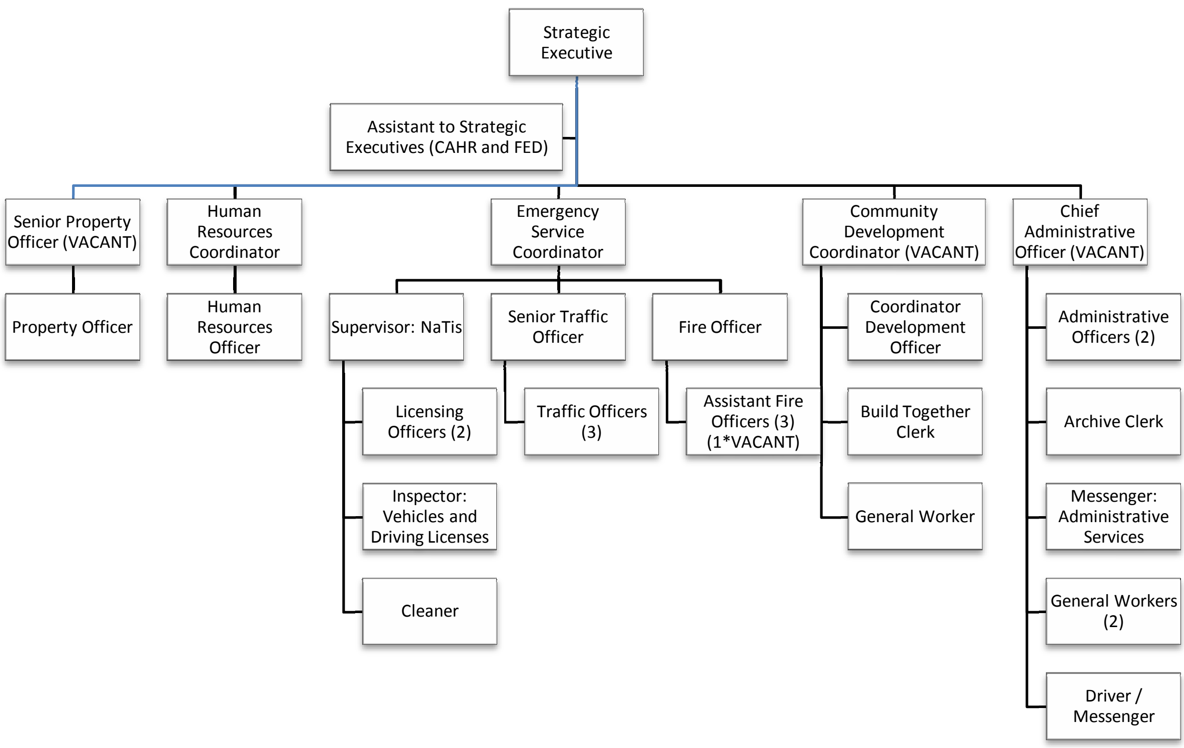


APPENDIX 2: ORGANIZATIONAL CHARTS OF KEETMANSHOOP

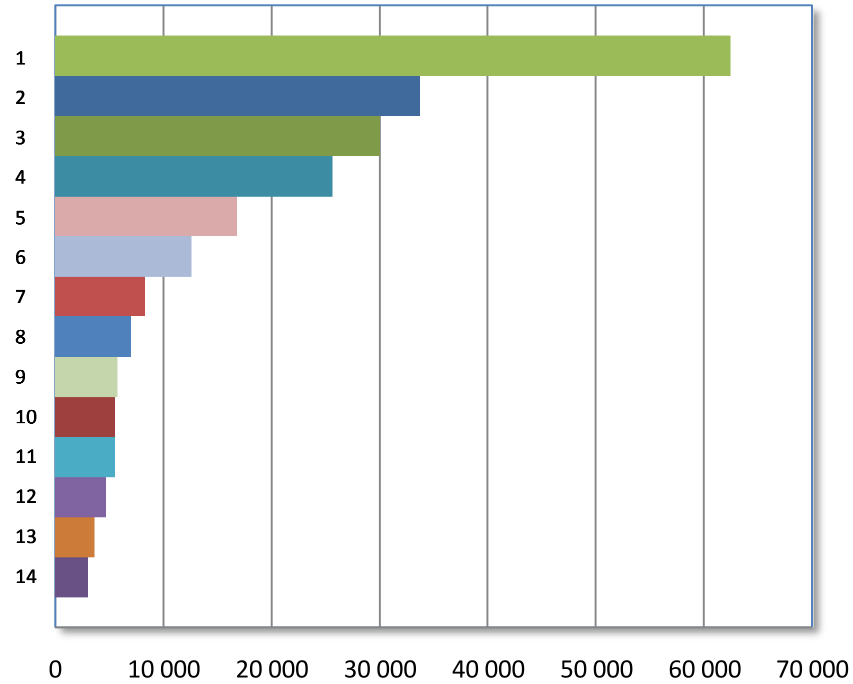
DEPARTMENT OF FINANCE AND ECONOMIC DEVELOPMENT



DEPARTMENT OF CORPORATE AFFAIRS AND HUMAN RESOURCES



APPENDIX 3: THE BIGGEST CONSUMERS IN KEETMANSHOOP



		Annual consumption m3
1	Krönlein hospital	62 435
2	P.K. De Villiers High School	33 703
3	Suiderlig High School	29 981
4	J.A.Nel Senior Sekondere Skool	25 614
5	Police	16 809
6	Prison	12 587
7	Canyon Hotel	8 272
8	Central Lodge	6 990
9	TransNamib	5 749
10	Multipurpose Youth Center	5 520
11	Ons Tuiste Old Age Home	5 526
12	Daan Viljoen Clinic	4 674
13	Bird's Mansion Hotel	3 593
14	St. Mathias Primary School	2 995
	Total	**241 590**

APPENDIX 4: AN EXTRACT FROM KEETMANSHOOP STORES' LOGBOOK

PIPE MATERIALS SUPPLIED BY MUNICIPALITY'S STORES

Table does not include quantities used by private contractors

Supplied lenghts:

uPVC	**6**	**m**
PE	**100**	**m**
AC	**4**	**m**
Galvanized	**6**	**m**

Type	Diam. mm	2007-2008 pcs	2007-2008 m	2006-2007 pcs	2006-2007 m	2005-2006 pcs	2005-2006 m
uPVC	160	18	**108**	31	**186**	27	**162**
uPVC	110	7	**42**	2	**12**	3	**18**
uPVC	90	5	**30**	14	**84**	11	**66**
uPVC	75	12	**72**	7	**42**	7	**42**
uPVC	63	12	**72**	8	**48**	-	**-**
PE	20*25	19	**1900**	16	**1600**	15	**1500**
AC	150	-	**-**	-	**-**	-	**-**
AC	125	1	**4**	0	**0**	1	**4**
AC	100	1	**4**	0	**0**	3	**12**
AC	75	-	**-**	-	**-**	-	**-**
galvanized	20	-	**-**	-	**-**	-	**-**
galvanized	15	-	**-**	-	**-**	-	**-**

		2004-2005 pcs	2004-2005 m	2003-2004 pcs	2003-2004 m	Started in general	Stopped in general	Supplied amounts (m)
uPVC	160	9	**54**	21	**126**	29.4.2003	-	636
uPVC	110	0	**0**	-	**-**	2.6.2004	-	72
uPVC	90	5	**30**	-	**-**	2.6.2004	-	210
uPVC	75	3	**18**	-	**-**	2.6.2004	-	174
uPVC	63	-	**-**	-	**-**	19.1.2007	-	120
PE	20*25	not stated	**not stated**	not stated	**not stated**	1980s	-	5000
AC	150	36	**144**	30	**120**	-	2005	264
AC	125	not stated	**not stated**	not stated	**not stated**	-	2005	8
AC	100	1	**4**	3	**12**	-	2005	32
AC	75	7	**28**	2	**8**	-	2005	36
galvanized	20	1	**6**	1	**6**	-	1990	12
galvanized	15	2	**12**	0	**0**	-	1990	12

WATER METERS SUPPLIED BY MUNICIPALITY'S STORES

Table does not include quantities used by private contractors

Type	Diam. mm	2007-2008 pcs	2006-2007 pcs	2005-2006 pcs	Started in general	Stopped in general
Sensus (plstc)	15	8	-	-	2008	-
Kent	15	149	219	230	-	-
Kent	20	33	72	84	-	-

APPENDIX 5: WATER METER TYPES IN KEETMANSHOOP

KENT
From left to right: 25 mm, 20 mm and 15 mm
Currently supplied by Municipality stores

Identification:
- Easily recognized from special shape
- Cannot be cleaned or parts replaced on the spot
- “Kent” text can be found from the utmost ring

SENSUS
15 mm plastic
Currently supplied by Municipality stores

Identification:
- Plastic water meter in a plastic box
- Cleanable and meter unit replaceable

ZENNER
From left to right: 20 mm and 20 mm
Currently not supplied by Municipality stores

Identification:
- Arrows pointing water flow direction in both sides
- “Zenner” text on the screen
- Air vent in special position (compared to other similar meters)
- Cleanable and meter unit replaceable

MEINECKE
From left to right:15 mm and 20 mm
Currently not supplied by Municipality stores

Identification:

- Arrows pointing water flow direction in both sides
- Air vent on top of the inlet
- Cleanable and meter unit replaceable

AQUA
From left to right: 15 mm and 20 mm
Currently not supplied by Municipality stores

Identification:

- An arrow pointing water flow direction together with big “H” letter on one side and size of the meter (mm) presented on the other side
- Air vent on top of the inlet
- Cleanable and meter unit replaceable

CASTLE (LATER KENT)
From left to right: 15 mm, 15 mm and 20 mm
Currently not supplied by Municipality stores

Identification:

- An arrow pointing water flow direction together with “Castle” text on one side and size of the meter presented on the other side together with other model information and “Horizontal” text
- Air vent on top of the inlet
- Cleanable and meter unit replaceable
- There is also a variation where air vent is on the side of the meter unit

APPENDIX 6: METER TESTING RESULTS IN KEETMANSHOOP

METER TESTING

Procedure: A five-liter container was filled on the top line and difference between meter recording and water level at the container was calculated. Also the container was tested and it was found out that five liter line was not very accurate. According to the calculations, only 4,545 liters fit under the five-liter line.

Average accuracy of water meters	**-0,09**	**liters**	**=> are over-billed per every 5 liters**
Average accuracy percentage	-1,7 %		

Suburb	Date	Meter no	Meter type	Prev. reading	New reading	Difference	Loss of water (l)	Accuracy
KRON	11.8.2008	122	Kent 15 mm	197,0	202,0	5	-0,45	-9,1 %
KRON	11.8.2008	830	Kent 15 mm	128,3	132,8	4,5	0,05	0,9 %
KRON	12.8.2008	733	Kent 15 mm	119,7	124,0	4,3	0,25	4,9 %
KRON	12.8.2008	329	Kent 15 mm	798,4	802,9	4,5	0,05	0,9 %
KRON	12.8.2008	332	Kent 15 mm	735,6	740,1	4,5	0,05	0,9 %
KRON	12.8.2008	591	Kent 15 mm	108,1	112,6	4,45	0,10	1,9 %
KRON	12.8.2008	57	Aqua 20 mm	2,1	7,5	5,4	-0,85	-17,1 %
KRON	12.8.2008	145	Zenner 20 mm	7,4	12,0	4,6	-0,05	-1,1 %
KRON	12.8.2008	666	Zenner 20 mm	7,0	11,9	4,9	-0,35	-7,1 %
KRON	12.8.2008	760	Castle 15 mm	5,0	10,0	5	-0,45	-9,1 %
NORD	11.8.2008	880	Meinecke 20 mm	4,5	9,0	4,5	0,05	0,9 %
NORD	11.8.2008	933	Kent 15 mm	34,0	37,6	3,6	0,95	18,9 %
NORD	12.8.2008	768	Castle 15 mm	2,2	7,0	4,8	-0,25	-5,1 %
NORD	12.8.2008	857	Aqua 20 mm	2,0	7,0	5	-0,45	-9,1 %
NORD	12.8.2008	180	Castle 20 mm	4,5	9,1	4,6	-0,05	-1,1 %
NORD	12.8.2008	270	Zenner 20 mm	5,6	10,0	4,4	0,15	2,9 %
NORD	12.8.2008	56	Kent 20 mm	542,9	547,3	4,4	0,15	2,9 %
NORD	12.8.2008	914	Meinecke 20 mm	9,6	14,8	5,2	-0,65	-13,1 %
NORD	12.8.2008	403	Kent 20 mm	487,1	492,4	5,3	-0,75	-15,1 %
NORD	19.8.2008	532	Zenner 20 mm	0,5	5,5	5	-0,45	-9,1 %
NORD	19.8.2008	619	Kent 20 mm	387,9	392,0	4,1	0,45	8,9 %
TOWN	11.8.2008		Aqua 20 mm	9,5	13,8	4,3	0,25	4,9 %
TOWN	11.8.2008	203	Zenner 20 mm	0,0	5,0	4,95	-0,40	-8,1 %
TOWN	11.8.2008	918	Kent 15 mm	634,1	638,6	4,45	0,10	1,9 %
TOWN	11.8.2008	916	Meinecke 20 mm	7,2	11,9	4,75	-0,20	-4,1 %
TOWN	11.8.2008	413	Kent 15 mm	256,1	261,7	5,6	-1,05	-21,1 %
TOWN	12.8.2008	391	Kent 20 mm	22,0	25,0	3	1,55	30,9 %
TOWN	12.8.2008	225	Kent 20 mm	182,6	187,1	4,5	0,05	0,9 %
TOWN	12.8.2008	946	Aqua 20 mm	4,0	9,0	5	-0,45	-9,1 %
TOWN	12.8.2008	288	Zenner 20 mm	3,0	7,5	4,5	0,05	0,9 %
TOWN	12.8.2008		Zenner 20 mm	4,1	7,9	3,8	0,75	14,9 %
TSEI	24.7.2008	924	Kent 15 mm	265,5	270,4	4,9	-0,35	-7,1 %
TSEI	24.7.2008	690	Kent 15 mm	808,5	813,2	4,68	-0,13	-2,7 %
TSEI	24.7.2008	140	Kent 15 mm	313,3	317,9	4,57	-0,02	-0,5 %
TSEI	24.7.2008	292	Kent 15 mm	973,4	977,9	4,5	0,05	0,9 %
TSEI	24.7.2008	493	Kent 15 mm	276,0	280,0	4	0,55	10,9 %
TSEI	24.7.2008	488	Kent 15 mm	217,0	221,0	4	0,55	10,9 %
TSEI	24.7.2008	765	Castle 15 mm	1,5	5,3	3,8	0,75	14,9 %
TSEI	24.7.2008	813	Kent 15 mm	308,9	313,3	4,35	0,20	3,9 %
TSEI	24.7.2008	590	Aqua 15 mm	9,1	13,4	4,3	0,25	4,9 %
TSEI	24.7.2008	710	Aqua 15 mm	7,7	12,2	4,5	0,05	0,9 %
TSEI	14.8.2008	49	Sensus 15 mm	2,0	6,4	4,4	0,15	2,9 %
TSEI	14.8.2008	10	Sensus 15 mm	5,0	**10,0**	4,95	-0,40	-8,1 %
TSEI	14.8.2008	48	Sensus 15 mm	5,5	10,0	4,45	0,10	1,9 %
TSEI	14.8.2008	731	Sensus 15 mm	2,5	7,1	4,6	-0,05	-1,1 %
TSEI	14.8.2008	44	Sensus 15 mm	7,0	11,4	4,4	0,15	2,9 %
WEST	11.8.2008	154	Kent 20 mm	660,1	667,6	7,45	-2,90	-58,1 %
WEST	11.8.2008	777	Zenner 20 mm	1,0	6,0	5	-0,45	-9,1 %

WEST	12.8.2008	21	Kent 15 mm	87,5	91,9	4,4	0,15	2,9 %
WEST	12.8.2008	53	Zenner 20 mm	3,2	7,9	4,7	-0,15	-3,1 %
WEST	12.8.2008	93	Castle 20 mm	4,6	9,2	4,6	-0,05	-1,1 %
WEST	12.8.2008	564	Castle 15 mm	6,5	10,9	4,4	0,15	2,9 %
WEST	12.8.2008	964	Aqua 15 mm	0,0	5,0	5	-0,45	-9,1 %
WEST	12.8.2008	604	Kent 20 mm	209,0	214,0	5	-0,45	-9,1 %
WEST	12.8.2008	461	Kent 15 mm	469,1	473,8	4,7	-0,15	-3,1 %
WEST	12.8.2008	123	Aqua 20 mm	5,0	9,9	4,9	-0,35	-7,1 %
WEST	12.8.2008	99	Castle 20 mm	1,5	6,0	4,5	0,05	0,9 %

TESTED METERS:	**Amount**	**Accuracy**
Kent 15 mm	18	0,9 %
Kent 20 mm	7	-5,5 %
Aqua 15 mm	3	-1,1 %
Aqua 20 mm	5	-7,5 %
Castle 15 mm	4	0,9 %
Castle 20 mm	3	-0,4 %
Meinecke 20 mm	3	-5,4 %
Zenner 20 mm	9	-2,1 %
Sensus 15 mm	5	-0,3 %

TOTAL:	57	

APPENDIX 7: KEETMANSHOOP MUNICIPALITY PROPERTIES' CONSUMPTIONS

Average consumptions were calculated from the difference between latest and previous legible readings.

		Average consumption		
Place	**Findings**	**m^3/d**	**m^3/m**	**m^3/a**
Parks				
Town				
Main street park island 1 (starting from the east)	no meter	0,03	1	**10**
Main street park island 2	active	0,23	7	**82**
Main street park island 3 (in front of the Mun)	active	0,24	7	**87**
Main street park island 4 (in front of the church)	active	0,26	8	**94**
Main street park island 5	active	1,19	36	**432**
Main street park island 6	meter broken	0,26	8	**93**
Palm trees 1	no meter	0,42	13	**153**
Palm trees 2	no meter	2,15	64	**777**
Town central park 1	active	24,42	733	**8841**
Town central park 2	active			
Calvex park island	active	0,84	25	**303**
Park outside caravan park	active	0,00	0	**1**
Westdene				
Playground 1	active	0,34	10	**122**
Playground 2	active	0,61	18	**220**
Playground 3	active	0,02	1	**8**
Central park 1	active	4,19	126	**1517**
Central park 2	active	0,83	25	**301**
Park island 1 (starting from the west)	meter broken	0,03	1	**11**
Park island 2	active	0,47	14	**170**
Park island 3	active	0,15	5	**56**
Park island 4	no meter	1,10	33	**398**
Nordhoek				
Central park 1	meter broken	5,34	160	**1932**
Central park 2	active	0,81	24	**294**
Krönlein				
Central park	active	0,15	5	**55**
Graveyards				
Town old	no meter	8,44	253	**3055**
Town new	no meter			
Krönlein	no meter	2,01	60	**727**
Tseiblaagte	no meter	1,49	45	**541**
Sportfields				
Westdene				
Grass (Rugby field)	no meter	18,80	564	**6806**
Show hall	active	4,71	141	**1706**
Krönlein				
Grass	no meter			
Tseiblaagte				
Toilets	active	3,92	118	**1420**
Grass (using borehole water)	meter broken			
Others				
Town				
Caravan park 1	active	12,75	383	**4616**
Caravan park 2	active	0,03	1	**10**
Swimming pool 1	active	99,79	2994	**36124**
Swimming pool 2	active	0,00	0	**0**

Plumbers garage	active			
Municipality stores	meter broken	4,31	129	**1559**
Tourism office	active	0,36	11	**129**
Museum (church)	meter broken	1,09	33	**396**
Fire Brigade's office	active			
Westdene				
Stables 1	active	2,43	73	**879**
Stables 2	active	0,36	11	**132**
Nordhoek				
Municipality garage	active			
Tseiblaagte				
Municipality office	active	4,86	146	**1760**
Krönlein				
Municipality office	active	0,09	3	**34**

TOTAL AMOUNT PER YEAR (m^3) **75852**

APPENDIX 8: KEETMANSHOOP MUNICIPALITY 2008/2009 FINANCIAL YEAR

Vote: Water (032)

Description	Budget 2008/2009	Budget 2007/2008	Year to Date 30.4.2008	Actual 2006/2007
INCOME				
Departmental sales				898 913
Sundries	12 000	12 000	4 718	16 129
Public sales	11 970 000	10 715 000	7 031 084	9 448 366
Total income	**11 982 000**	**10 727 000**	**7 035 802**	**10 363 408**
EXPENDITURE				
Staff expenses				
Salaries & Allowances	380 416	281 852	308 302	447 515
Leave Bonus	31 701	23 488	32 005	34 921
Fuel & Vehicle Allowance	36 000	36 000	18 200	25 400
Social Security	2 579	2 579	2 382	3 015
Medical Contributions	79 734	65 897	21 174	28 638
Pension Contributions	81 789	61 162	57 707	82 317
Overtime	30 000	10 000	72 727	100 719
Housing Allowance	32 950	28 185	19 940	21 992
Standby Allowance	25 000	59 010	10 812	13 990
Total staff expenses	**700 169**	**568 173**	**543 249**	**758 507**
General expenses				
Fuel	50 000	45 000	34 882	39 772
Administrative Levy				
Protective Clothing	6 000	6 000	2 968	4 957
Cleaning Materials	2 000	2 000	822	1 945
Vehicle Registration	2 000	2 000	1 260	1 080
Water Purchase - NamWater	10 200 000	8 700 000	5 929 672	9 923 118
Treatment Water	15 000	15 000		
Water consumption				221 562
Printing & Stationary	2 000	3 000		
Total general expenses	**10 277 000**	**8 773 000**	**5 969 604**	**10 192 434**
Repairs & Maintenance				
R&M Tool & Equipment	20 000	21 060	485	23 891
Machinery & Equipment	8 000	10 000	629	7 349
Network	300 000	300 000	201 120	266 160
Vehicles	6 000	5 000	5 423	3 040
Contracts	200 000	200 000		
Total R&M expenses	**534 000**	**536 060**	**207 657**	**300 440**
Redemption and Interest				
Interest on External Loan	30 000	30 000	22 843	104 108
External Loan Redemption	16 000	16 000	13 892	17 198
Total redemption & interest	**46 000**	**46 000**	**36 735**	**121 306**
Capital Outlay				
Fencing	40 000	50 000	3 485	
Prepaid water machines		120 000	8 510	
Chlorine Plant		120 000		
Auxillary Pipe				
Vehicles		36 000	11 029	217 259
New Tools	15 000	15 000		
Total capital outlay	**55 000**	**341 000**	**23 024**	**217 259**

Total expenditure	**11 612 169**	**10 264 233**	**6 780 269**	**11 589 946**
Less: Charged Out				
Net expenditure	**11 612 169**	**10 264 233**	**6 780 269**	**11 589 946**
Surplus/(Deficit)	**369 831**	**462 767**	**255 533**	**-1 226 538**

APPENDIX 9: PHOTOS FROM KEETMANSHOOP

Photo 1 *Main street © Risto Seppänen*

Photo 2 *Shacks in Tseiblaagte © Risto Seppänen*

Photo 3 *Reservoir not in use (Tseiblaagte borehole) © Risto Seppänen*

Photo 4 *NamWater reservoirs on Oxpass hill © Risto Seppänen*

Photo 5 *Boost pump station to Keetmanshoop airport © Risto Seppänen*

Photo 6 *Typical shut valves and bricklaying © Risto Seppänen*

***Photo 7** Water meter has been stolen (Town graveyard) © Risto Seppänen*

***Photo 8** Leaking water meter and valve (J.A. Nel Senior Sekondere Skool) © Risto Seppänen*